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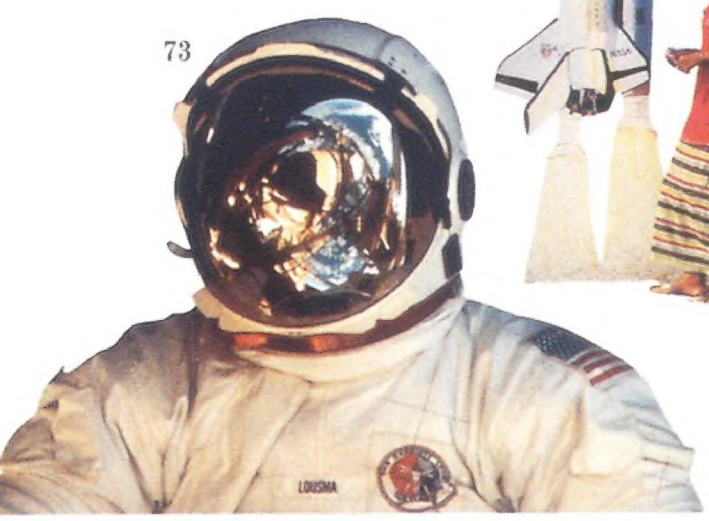
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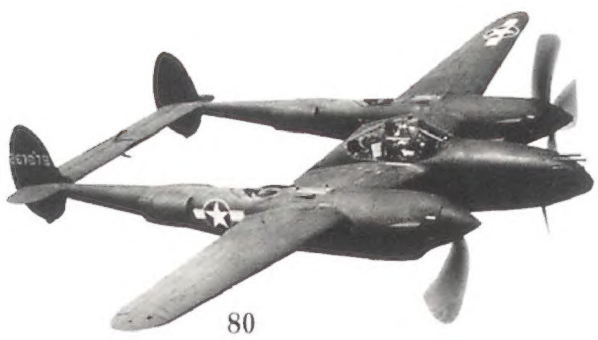
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Cover:
Photographer Chad Slattery looks a pararescueman in the face.

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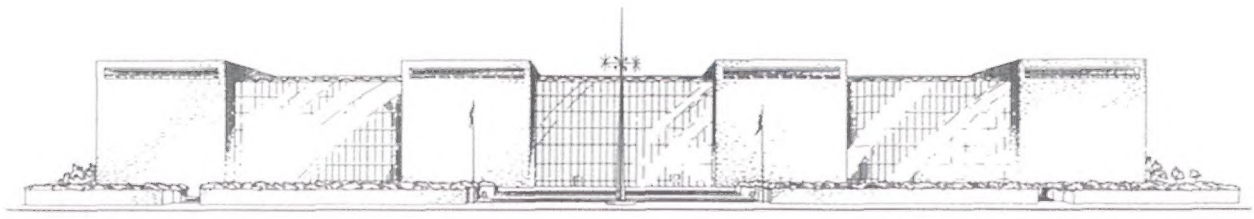

The Museum Extension: A Reply

I have recently received a number of inquiries from different parts of the country, asking how a museum or locality might enter the competition for the National Air and Space Museum extension. The issue calls for an open response, particularly if other communities are contemplating the same question.

Shortly after World War II, Paul Garber, the Smithsonian's senior curator for aviation, began to search for a facility that could temporarily house the Institution's growing aircraft collection. A site was found just outside the Washington city limits, in Suitland, Maryland. Today, rusting temporary structures of 1940s and 1950s vintage, without any thermal or humidity control, still house some of the nation's most valuable aviation and spaceflight artifacts at the Museum facility now bearing Paul Garber's name. Insects and birds nest among national treasures, inexorably accelerating their deterioration.

By the early 1980s the situation had reached critical proportions. To be sure, astronaut Michael Collins had opened our wonderful new Museum on the Mall in Washington in 1976 to celebrate the nation's 200th birthday. But the Museum has no restoration facilities, virtually no exhibits preparation or maintenance shops, and no archival storage. The Museum's primary purpose has been to mount exhibitions for the public. And because today's largest airplanes and spacecraft can be brought only as far as the nearest airport, difficulties are encountered in the exhibition of modern aviation and spaceflight.

Recognizing these problems, the Museum began in 1981 to search for potential extension sites meeting the following requirements:

The extension would need permanent access to an active runway capable of handling large jet aircraft.

The extension could not interfere with the primary mission of the airport, but also required sufficient acreage for current needs and future expansion and would need the support of airport and local authorities.

To permit the transfer and incorporation of all the functions currently carried out at the Garber facility, the extension would have to be easily reached by the Museum's staff on the Mall. This restricted the extension's location to a radius of an hour's journey.

In the 1980s the Museum examined every airport within this range. Ultimately only two locations met all criteria, the Washington/Dulles International Airport and the Baltimore-Washington International Airport. The Smithsonian Institution's regents found that the Dulles site had advantages, and the three senators and three members of the House who also serve as regents introduced authorizing legislation in both houses of Congress.

A countervailing bill has now been introduced proposing that the site selection be opened to the entire country, and that distance from the Museum not be a prime criterion disqualifying a site.

This proposal seems to me to have two major difficulties.

The nationwide search for a facility will prove time-consuming and costly. The Smithsonian has already spent half a million dollars and two years of work on site selection. If, as seems likely, another two dozen sites across the country start competing for the extension, several further millions and added years will have to be expended. In the meantime, deterioration will continue to take its toll on spacecraft and aircraft.

An extension at a distant site will also require the Museum's collections to be split and will lead to grave difficulties in preparing and maintaining the exhibits for the Museum on the Mall, effectively threatening the future of the world's most visited museum.

The Museum desperately needs a nearby extension and needs it now. I continue to hope that reason will prevail.

—Martin Harwit is the director of the National Air and Space Museum.

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Letters

Fate Remains the Hunter

After reading "Fate Was the Hunter" by Jerry Slocum (October/November 1991), I have a couple of observations. Like Slocum, I was deeply influenced by Ernie Gann's classics: *Fate Is the Hunter* and *The High and the Mighty.* But I would disagree with Slocum's assertion that "fate seems to have been reduced to the joker in the deck." One need only remember the Aloha Airlines structural failure, Air Florida's plunge into the Potomac River, or Captain Al Haynes' struggle to save a DC-10 crippled by complete hydraulic failure to realize that fate remains the hunter. Gann's message is as relevant today as it was when it was written.

By the way, in 1987 I had the fortune to be in command of a Military Airlift Command C-141 transport with Gann aboard as a mission observer (he was en route to the Far East to complete research for his book *The Black Watch*). After two legs over the ocean, Gann was quick to note the emphasis MAC places on crew communications, checklists, and other cockpit resource management concepts.

Colonel Michael R. Gallagher
Scott Air Force Base, Illinois

The Clothes That Launched a Single Complaint

In "The Faces That Launched a Thousand Ships" (Soundings, December 1991/

January 1992), a NASA engineer says, "People think we're all crew-cut squares wearing ties, and we're out to change that." I couldn't be more in favor. But just six pages later, you ran a photograph of a Kennedy Space Center control room full of engineers in white shirts and ties and some even in dark suits—the square uniform of the '60s. Personally, I wish it had died with that era. Do they really have to dress like that?

Roger A.C. Williams
Boulder, Colorado

Top Secret

The huge red "SECRET" stamps emblazoned over the pages of "The Spies in Space" by Jeffrey T. Richelson (December 1991/January 1992) raise the question: If the pages are SECRET, why did you publish them? Does *Air & Space/Smithsonian,* as a matter of policy, confer with anyone in the executive or legislative branch about whether it is in our best national or international interests to publish an article that appears to need big red SECRET stamps?

Scott L. Schneberger
Marietta, Georgia

Editors' reply: The stamp was merely a graphic design device.

Credit Where Credit Is Due

"Satellite Fishing" (In the Museum, December 1991/January 1992) states, "Thanks to a LACROSSE radar satellite, Desert Storm military brass were informed of Scud missile attacks within 120 seconds of launch." That praise should actually go to the spacecraft that make up the Defense Support Program missile early-warning system in geosynchronous orbit. It was those satellites that warned Patriot missile batteries of 88 Iraqi Scud missiles launched against Israel and Saudi Arabia.

Melvin H. Schuetz
Bedford, Texas

Accidents Will Happen

"Wings of the Great War" (October/November 1991) was of special interest to me. How true it was that "accidents in training were everyday occurrences." In 1916 my father joined the Royal Flying Corps in Canada as an airplane mechanic. As he told it, life was just one crash after

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A SWEDISH OBSESSION

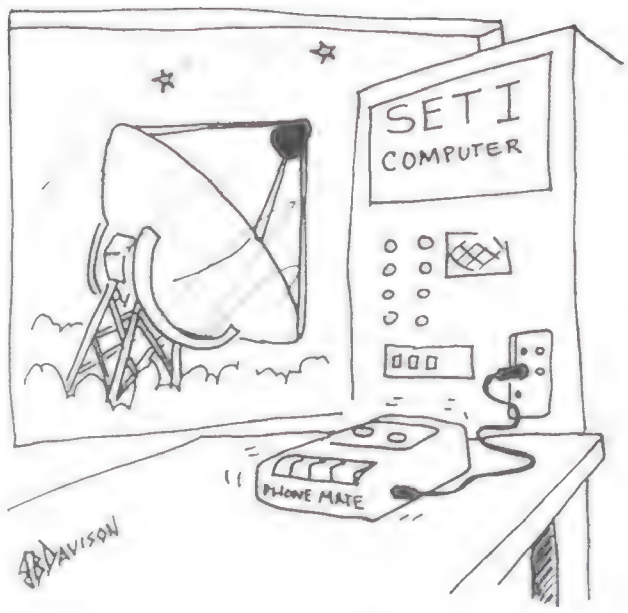
another. To help himself cope with the carnage, he resorted to humor by drawing cartoons about life in the squadron.

John Hendry Jr.
Chicago, Illinois

Striking a Nerve

I think Jeff Ethell was a bit too kind in his gentlemanly response to Donald L. Newell (Letters, December 1991/January 1992). Newell implied that, not being a man of iron, Ethell failed himself and your readers by not fully exploiting his opportunity to fly the vintage fighters of World War I. I just wonder why Ethell's honest statement that old warbirds were miserable to fly would cause "anger [and] disbelief" for Newell.

Herbert R. Rutland
Newtown, Pennsylvania



"Hi, this is Earth! At the sound of the tone, please leave the name of your star and distance in light-years. We will return your call as soon as possible..."

Hotshots

I was extremely angered by "A Single Daring Act" (October/November 1991) but greatly relieved by Colonel Phillips D. Hamilton's clarification (Letters, December 1991/January 1992). I was a former crew chief in "C" flight, 335th Fighter Squadron, Fourth Fighter Group (the original Korean War contingent), and the last thing we needed was a hotshot pilot who totally disregarded the rules. Sabrejets were very scarce, and totalling one due to ignorance was, in my opinion, a court martial offense. We were kept busy enough with the "bomb line" pilots who flew north just far enough to get credit for a combat mission. Then they would claim a mechanical problem and return to base, leaving us to waste time chasing imaginary problems. We caught hell until the powers that be realized what was happening.

The only real stupidity I recall was when a cocky new pilot landed a new Sabre with the gear up. For punishment, he had to assist the aircraft maintenance crew chief in repairing the slightly damaged Sabre. And I remember that discipline was so rigorous that if a Sabre's external fuel tanks failed to drop in combat, the maintenance chief lost a stripe.

Albert N. Kalow
Ravenna, Ohio

Unidentified Flying Object

Can you identify the aircraft in this photograph? From time to time the National Air and Space Museum's archives division receives photos of vehicles that its staff cannot identify. They would appreciate any help in naming this month's rather strange-looking hydroaeroplane and the quartet of gentlemen ranged in front of it. The caption reads: "Tell City, Indiana, 1914, hydroplane." Noteworthy is the position of the engine and drive system. If you think you can solve this mystery, send your response to: Air & Space/Smithsonian, *Department ASP, 370 L'Enfant Promenade SW, 10th Floor, Washington, DC 20024.*

Waterworks

"By Airship to America" (Above & Beyond, December 1991/January 1992) brought back memories of my past. In June 1939 I was a member of class VIII of the Naval Airship Training School in Lakehurst, New Jersey. Your article mentioned rain gutters used for collecting water to compensate for a drop in fuel weight and, while landing, to use as ballast. The *Akron* and *Macon* designers solved the fuel weight loss problem by incorporating a water recovery system in the exhaust of the eight Mayback VL-II 12-cylinder engines.

H.T. Chambliss Sr.
Mountain View, California

Dances With Clouds

"Why We Fly" by Peter Garrison (Moments & Milestones, August/September 1991) was a beautiful description of just how good plain flying can be. Garrison's writing is apt for passengers and some people who fly airplanes, but I feel it badly misses in expressing the essence of being a pilot.

A pilot is a flier who becomes one with the machine and who works together with it to produce a symphony of three-dimensional movement *in* the air, as opposed to primarily two-dimensional movement *through* the air. I take particular exception to Garrison's statement that "one cannot dance with it [a cloud]; anyway an airplane cannot dance, but only lunge in slow motion." If

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Garrison is a pilot, I suppose he is a bomber or a transport jockey, which is not to say that I disrespect bomber and transport jocks. Indeed, I have known several who were fighter pilots at heart, and I have known pilots flying fighters who should have been doing something else. I've heard it said that bomber jocks are people interested in aviation who care little about flying.

A true pilot will turn the airplane every which way but loose, flying with grace and balance so that in a series of maneuvers the end of one flows indiscernibly into the beginning of the next. You can move in any direction, including straight up and straight down. This is a suitable definition of dancing in the sky. Of course, big bombers and transports cannot safely do snap rolls and strenuous negative-G maneuvers, but they can loop and barrel roll and even slow roll. These are things an airplane driver with a fighter pilot's heart would do no matter what kind of aircraft he or she was flying. The pilot would hear in his or her mind a waltz or processional music to accompany the flight.

John J. Simon
Aurora, Colorado

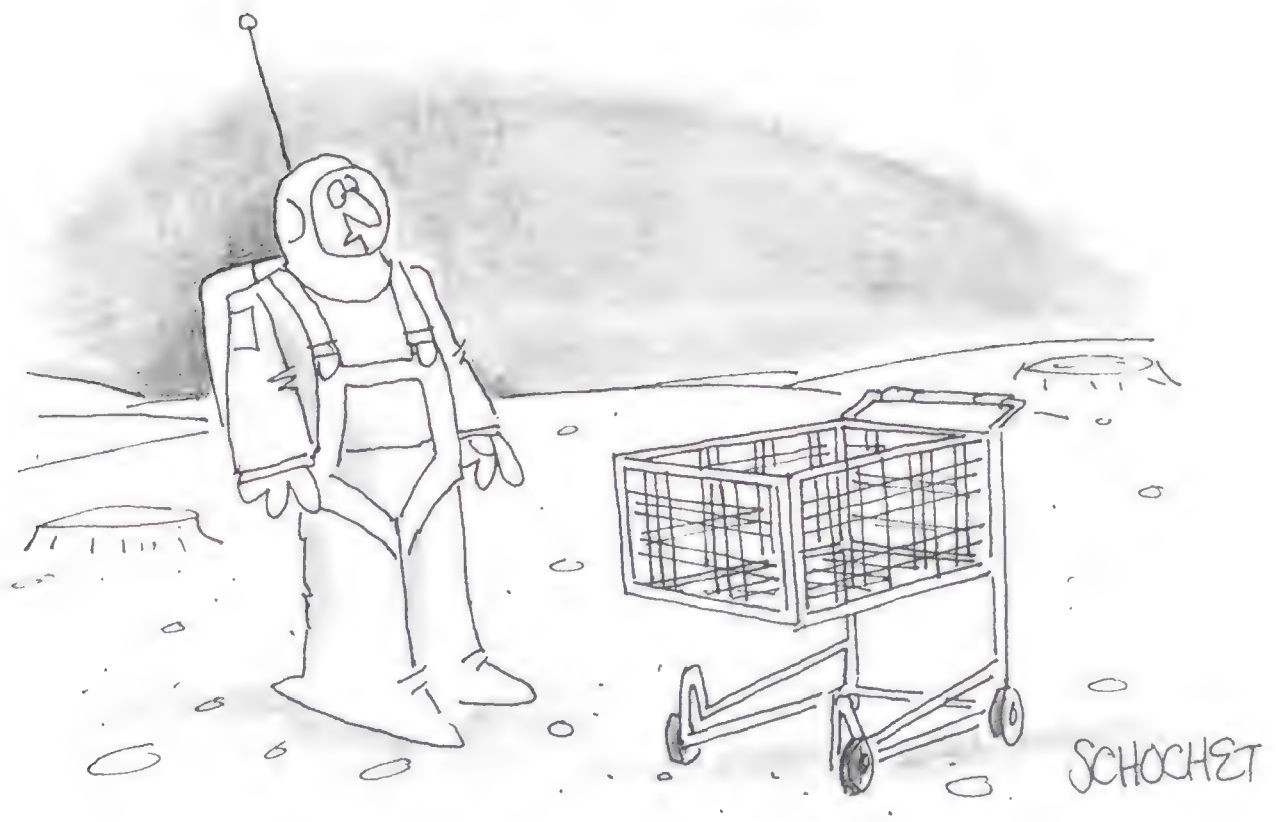
Lay Down Your Arms

As a former member of the Ninth Special Operations Squadron stationed in Nha Trang, Vietnam, I was disappointed that "Two Engines, Jungle View" (In the Museum, October/November 1991) failed to mention the use of the O-2 in psychological warfare. The O-2B included a loudspeaker system for broadcasting to enemy forces below while the crew simultaneously bombarded them with leaflets. It was used extensively by the Ninth SOS flying out of Nha Trang, Pleiku, and Da Nang. I can't provide exact figures, but I know that the strategy was effective in getting many North Vietnamese and South Vietnamese communists to give up.

Lieutenant Colonel Glen L. Diehl
U.S. Air Force (ret.)
Huntsville, Alabama

Corrections

As the great-grandson of Samuel F. Cody, I would like to comment on some inaccuracies in "The Cowboy and His Kites" (Oldies & Oddities, October/November 1991). Since Cody's wife, Lela, was never divorced from her first husband, Edward King, she and my great



grandfather, though they lived together, weren't actually married. And though Lela had three sons and a daughter from her marriage to King, she and Cody had only one child together, a boy named Samuel (my grandfather). According to your article, Cody bought a box kite for his son Vivian. But of course Vivian was not really his son, and I feel that if any kite was bought, it would have been for Cody's real son, Samuel, who was four years old at the time. Your article also states, "Cody never took any woman aloft save his wife," but I have photographs of the wife of Colonel Capper (my great-grandfather's boss) being taken up in the airplane. My great-grandfather took up both men and women in his airplanes; he even had female pupils.

Samuel Franklin Colin Cody
Kent, United Kingdom

The title of Carl Posey's latest novel is *Bushmaster Fall* (Credits, December 1991/January 1992).

In "The Biggest Little Airplanes in Texas" (December 1991/January 1992), a model R4D, the Navy version of a DC-3, was incorrectly labeled a C-47.

We welcome comments from readers. Letters must be signed and include a daytime telephone number. Letters may be edited. Write to Air & Space/Smithsonian, *370 L'Enfant Promenade SW, 10th Floor, Washington, DC 20024.* Air & Space *is not responsible for the return of unsolicited photographs or other materials.*

Max Q Puts the Rock in Rockets

Some kids may think flying in space is the ultimate career, but six NASA astronauts who've realized their childhood dreams now confess they'd rather be...

A concert pianist. A drummer in a rock band. Elvis.

"If I could trade places with anybody—and if he'd do it—I'd swap with Mick Jagger," says Kevin Chilton, who will pilot the shuttle *Endeavour*'s first flight this spring. "I'd be a rock star, and he could come be an astronaut." Chilton and five other astronauts toil in swift jets and mock shuttles by day, and by night they play out their fantasies as Max Q, an all-astronaut band.

Max Q (rocket scientist talk for maximum aerodynamic pressure; a launching shuttle can withstand 580 pounds per square foot) was launched in 1987 at an astronaut office sock hop in League City, Texas. Fueled by word-of-mouth advertising, the band (not to be mistaken for a major label combo with the same name) has taken off. The six astronauts entertain at most Johnson Space Center employee outings and play weddings and corporate cocktail parties every now and then. Occasionally they take the stage in Houston area lounges, but "we don't need to quit our daytime jobs, I'll put it that way," says Max Q's ever-modest lead guitarist Robert "Hoot" Gibson, captain of the Spacelab shuttle mission planned for September.

Gibson and drummer James Wetherbee, who will command the deployment of a geological research satellite in November, are the only original Max Q members. Solar Max repairman George "Pinky" Nelson (bass), shuttle captain Brewster Shaw (rhythm guitar), and astronomer Steven Hawley (keyboards) quit the band when they left the astronaut corps.

All the present members were musical youngsters except guitarist Chilton, who tried the clarinet before high school and says, "For all the squeaks and squawks I put out I'd have been a better duck hunter than a clarinet player." He fiddled with a guitar he got in college but never played

in public before his first Max Q gig in 1989. Leading the band's rendition of the Rolling Stones' "Start Me Up" is "kind of my Walter Mitty," he admits.

"I think all of us have the feeling we can't live a full life unless we're playing music," says keyboard player Susan Helms, perhaps the most accomplished musician of the bunch. Helms almost became a professional pianist instead of an aeronautical engineer. Stationed with the U.S. Air Force in Canada, she played in three bands before being discovered by Steven Hawley, who quizzed her about musical instruments when she appeared before the astronaut selection board in 1989. "When I told him I owned a couple of pianos his eyes lit up," Helms recalls. "It didn't hit me until later that I was a potential not just for the astronaut corps but also as a replacement for him on Max Q."

Back home in Cleveland, saxophonist-vocalist Carl Walz sang with a 1950s revival band before joining the Air Force. He auditioned for Max Q last year after word got back to Houston that he'd sung a few Elvis Presley-style numbers with a band in a Washington State bar, where he and other astronaut trainees were celebrating the end of a survival training expedition.

Their day jobs don't leave much time for their hobby. "When you get six people in various phases of flight training, it gets kind of tough," says bass player Pierre Thuot, who played trumpet in junior high school and later taught himself how to

PETER HEMENWAY

play guitar. He and the others steal an occasional weekend night to practice, but even a jam session requires artful scheduling when a shuttle is about to fly. "One time we practiced with one of the guys in quarantine," Chilton says. So far Max Q has never missed a date, but "there's always a caveat when we book a gig," says Chilton. "We always say something may come up: 'Someone may have to go to Africa or Florida or fly in space, you understand?' "

Without their blue NASA jumpsuits, the astronauts often go unrecognized on stage—and they prefer it that way. "At gigs like that you have to play like a musician or you won't get asked to come back," says Wetherbee, who once dreamed of drumming in a rock band. Max Q's repertoire of a hundred songs spans the 1950s to the '80s, with a few '90s tunes for good measure. But matching the mix with the audience seems to be the biggest problem. "We don't play any country-and-western songs," Wetherbee says, "and we don't know any Def Leppard songs. I think I know a lot of different bands, but I guess I'm surprised that some people have never heard of the Everly Brothers."

—Beth Dickey

A Case of Stage Flight

Some may not consider "Flight," a six-part, nearly hour-long dance performed by the Everett Dance Theatre, to be high art. It certainly isn't classical ballet, and it's anything but solemn, mixing live and taped narration, audience participation, and silent-movie slapstick to music ranging from Chopin to Glenn Miller. The piece, which premiered in New York City in 1989, has since toured the country. Last November it came to Suffolk University's C. Walsh Theater in Boston.

"Flight" began as an abstract concept involving wind, shapes, and images, says choreographer Dorothy Jungels, but when two dancers began fooling around with pieces of plywood, forming symbolic airplanes, "we felt we had been visited by Wilbur and Orville."

Portraying the Wright brothers, Jungels' son Aaron and Marvin Novogrodski play with boards of several lengths, tumble across each other like gymnasts, and exchange German doubletalk (the Wrights were studying German so they could read Otto Lilienthal's work). Other early aviators in flight suits and leather helmets strut across the stage, chase one another, and collapse in heaps.

The perils of barnstorming are alluded to in a carnival-like segment in which barkers stride into the audience and offer toy aircraft in exchange for play money enclosed in the programs. "Plane smashes into automobile, $400; plane explodes in midair, pilot shoots out, $1,500," a barker shouts, demonstrating with props. A female audience member was taken into the blue yonder sitting on long poles hoisted on dancers' shoulders. "Don't ever forget that we're capitalizing on sudden death," says one performer, injecting a somber note into the boisterous proceedings.

As Amelia Earhart, Rachael Jungels, the choreographer's daughter, is an appropriately determined aviatrix. Some of this segment aims at profundity and falls short, but the end has an elegance as the character strips down from flight suit to bathing suit, swimming the breaststroke into history as Jungels' recorded voice recites a passage from an Earhart letter to her family to be opened in the event of her death: "I have no faith that we'll meet anywhere again, but I wish we might." Silky windsocks are billowed by floor fans, evoking old musicals.

The four dancers and the choreographer have created a spirited celebration of the strut, wing, and cockpit that you can take the kids to. In fact, the company, no dance-studio hothouse flowers, has taken "Flight" to elementary and middle schools. "We do desire to be accessible," Dorothy Jungels says. "It's not necessary to be obscure for the sake of being obscure."

Jungels does let on that her father, whom she never knew, was a pilot in the 1930s. "He actually just vanished," she says, "but not in a plane."

—Wes Eichenwald

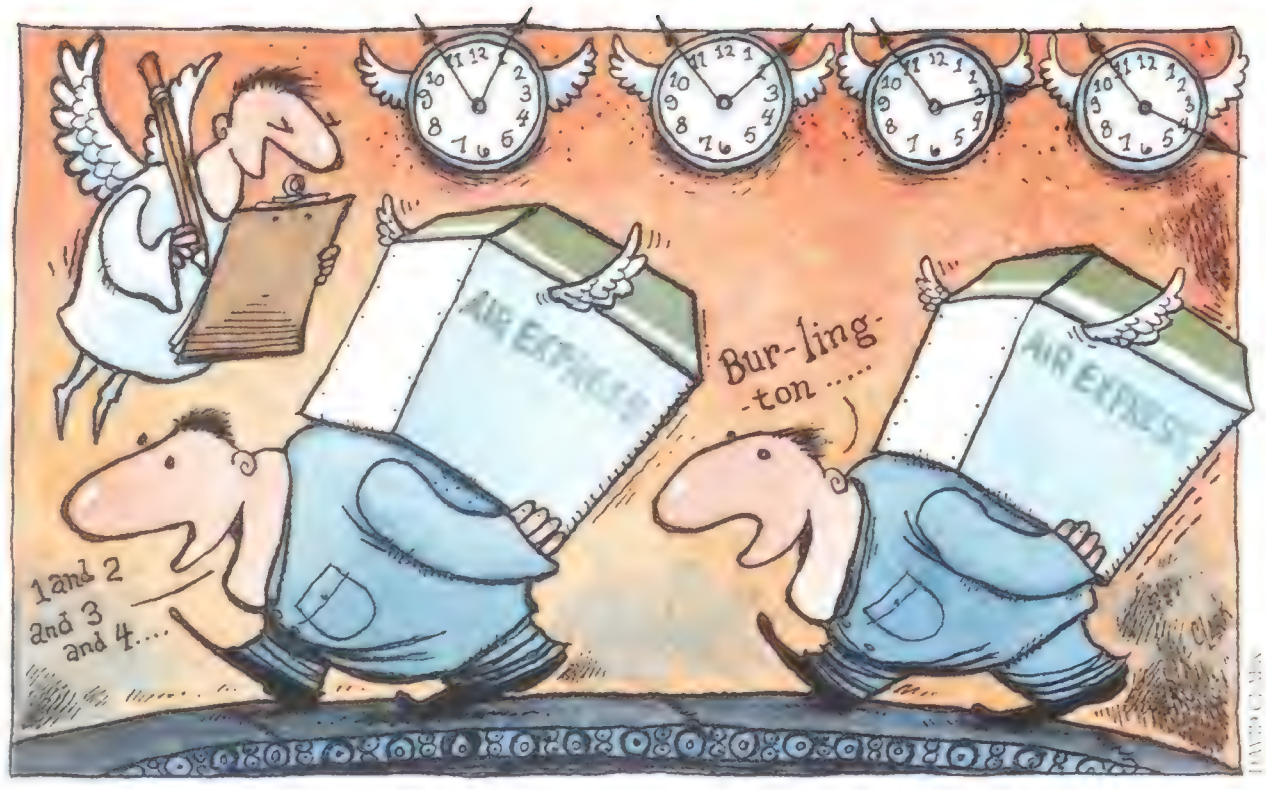
Update

Aviation Writer Dies

Ernest K. Gann, prolific author of aviation novels and autobiographies ("Fate Was The Hunter," October/November 1991), died last December 19 at his home in Washington State. Gann, who was 81, had suffered from kidney ailments. His last book, "The Black Watch," described the lives of pilots in U-2 squadrons.

Lift That Bale, Tote That Air Freight Container

A column of numbers on a chart at the Burlington Air Express control center had Glen Beecher in a good mood. Nineteen green numbers represented nineteen airplanes that had taken off from nineteen airports on time. They were due to converge on this Toledo freight sorting facility during the next four and a half hours, along with three airplanes whose registration numbers showed up on the board in red. Those three left late. "All you have to do is look at the colors in that column to know what kind of night it's going to be," said Beecher, Burlington's vice president of air operations.



It was just about midnight on a Wednesday in Toledo, and most of the city had already turned in. But because thousands of people all over the country would wake up tomorrow morning expecting a package, some 500 people in Toledo were just getting to work at Burlington's brand-new $75 million, 279,000-square-foot freight hub. Between now and 4:30 a.m., they would unload one million pounds of freight from 22 airplanes, sort it by destination, reload, and send it on its way. Most of the packages would arrive by 10 a.m.

Beecher's colleague Bernie Trainor, who had helped design the new facility, was also in a good mood. Burlington's vice president of hub services and development, Trainor showed a group of reporters around "the sort," something he obviously enjoys doing. Trainor, a big man whose father was a trucker, looks like he's been around freight distribution all his life. "In the first month of business, I performed every operation in the building and on the ramp," Trainor told the reporters. No one doubted it.

Even the freight handlers seemed to be in good moods. In groups of 15, teams stationed throughout the warehouse-like building were doing jumping jacks in preparation for the night's labor. As each team finished its calisthenics, the members shouted a cheer: "BUR-LING-TON-AIR-EX-PRESS-ON-TIME-NO-MIS-SORTS!" which seemed a vaguely Japanese form of morale boosting. A local television reporter commented later that Toledo, yoked to the fortunes of the automotive industry, was happy to get the 500 part-time jobs, which may explain the spiritedness of the freight handlers at that hour of the morning.

In the rest of the overnight delivery industry, freight enters a sort at one end and leaves at the other; every package must be handled. Burlington built its new hub so that freight could arrive at any of 10 modules, which are keyed to aircraft destinations. Every package entering the hub has been marked with a number between one and 10 representing its destination. Because the hub has 10 receiving areas instead of one, some packages enter at their destination module and never have to leave the door they enter until it's time to get back on an airplane. Trainor says the modular system has improved Burlington's turnaround time at the hub by 20 percent.

It was close to 1 a.m. when the sort came alive. A vast network of conveyor belts and slides, the sort moves packages weighing less than 70 pounds from one module to another. Heavier freight, the bulk of Burlington's business—space shuttle engine parts one night, a 22-foot, half-ton Christmas tree for the White House another—travels by forklift. Automobile and airplane manufacturers are big customers.

Handling a million pounds of freight that has to get somewhere by the next morning sounds like frantic activity, but even at 2:30, when most of the aircraft had been unloaded and packages of all sizes were scooting along the belts and being scooped from slides, the process seemed calm, almost sluggish. (The sort has the capacity to handle four million pounds of freight, which may may explain the leisurely pace with which one million pounds waltzes through.) Only the forklift operators appeared to be working in fast-forward, streaking from module to module.

Trainor, who seemed to know all of the handlers by name, looked as though he would continue clapping shoulders and grinning all night, but at 3:30, when most of the airplanes' freight containers had been emptied and refilled, he headed back to the offices, reporters in tow. As the tour group buttoned up against the early morning cold and somebody in the office phoned out for lunch ("No, make that five chili dogs"), it was tempting to think about the people who, perhaps sleeping fitfully at that very moment, would in a matter of hours bless the name of Bernie Trainor—if only they knew it—the guardian angel of procrastinators everywhere.

—Linda Shiner

NASA/JPL

Despite a stuck antenna, the Galileo spacecraft successfully rendezvoused with the asteroid Gaspra last October, coming within 1,000 miles and snapping 150 photos for NASA's scrapbook. Elated project scientists at the Jet Propulsion Laboratory in Pasadena, California, getting their first close-up look at an asteroid, described it as resembling "an island the size of Oahu," "a very, very interesting object," "a shark's head," and "the head of a salamander." An informal poll of laypeople in the Washington, D.C. area elicited comparisons to "an unadorned Mr. Potato Head," "an Isotoner slipper for someone with gout," and "a big lumpy rock."

Update

Gold Cards?

The first series of SpaceShots, collectible cards featuring space history and trivia (Soundings, April/May 1991), has increased nearly 40 percent in value since its debut late in 1990. According to *The Non-Sport Marketplace*, the 110-card set, which originally sold for $18, now fetches $25 in collectors' circles.

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A Grave Warning

For the past couple of years, pilots who have requested a listing of general notices when filing flight plans with the Federal Aviation Administration have found the following bulletin among the routine warnings about runway closings, inoperative lights, and malfunctioning navigation devices:

The Federal Aviation Administration is advising all operators of private or commercial aircraft that the government of the Republic of the Philippines prohibits the transportation by aircraft of the remains of Ferdinand Marcos into the airspace of or landing or disembarking in the Republic of the Philippines. Pursuant to Resolution No. 218-A, the Philippine government has stated, "Any violation of this directive shall subject the airline/aircraft operator to the maximum penalties provided for by existing laws which may include the impounding of the aircraft."

Euroshuttle: On Hold

Last November in Munich, Germany, the European Space Agency held its first high-powered pow-wow since 1987. Ministers were supposed to give the final okay to the Hermes shuttle and the Columbus orbital laboratory. Instead, they put off decisions on manned programs and resolved to seek technical and industrial assistance outside Europe, notably from the Commonwealth of Independent States—until recently, the Soviet Union.

Though long-term strategy through 2005 was approved, decisions on the future of ESA's Hermes, Columbus, and a data relay satellite were deferred until late next year, when the ministers will meet in Spain. The reason for the delay was Germany. ESA nations, though cash-strapped, would have been willing to continue funding the Euroshuttle, but their number-two space power is short one billion deutsche marks ($625 million) due to a program of its own called reunification. Earlier last year Bonn got ESA to reduce Germany's contribution by 15 percent, and at Munich they wangled another five percent. The Germans are also counting on their economy to pick up by the next ESA money meeting. Heinz Stoewer, director of space utilization programs for DARA, the German space agency, said, "If we had voted today, Germany's percentage would have been zero." And without the Germans' 27 percent share, Hermes is a scuttled shuttle.

The Munich decision did not give an automatic green light for Hermes in 1992. Like any ESA project, a two-thirds vote can snuff it out—and with it, Europe's hope of rocketing into space's manned

major leagues. Nonetheless, the agency will proceed as if the go-ahead is a given. Most Munich participants were optimistic, or at least said they were. But industrialists worry that this year might be the shuttle's last. Claude Guionnet, deputy director for Hermes at Matra Marconi Space France, where he has already had to cut 30 from his staff of 100, laments "demotivation" of the workforce. "People want to get on a project that's moving," he says. "I have to put them on something else, and I'm a little pessimistic."

With everyone fighting over Hermes (or more precisely, with everyone fighting the Germans over Hermes), Earth observation emerged the big winner. ESA's environmental project, a polar-orbiting platform lyrically called POEM (a loose acronym for Polar Platform Earth Observation Missions), suddenly became the conference's pet. At least it was something they could agree to act on: the project got the coveted consent, though only preliminary studies were funded. "Every delegation spoke enthusiastically about it," said one participant. "It was a real unifying force. It's obvious that the environment is higher up on the political agenda now than manned spaceflight."

As the conference ended, delegates were breezily imagining ESA/CIS joint ventures, though they were quick to add that shopping outside the continent did not mean that the Europeans have reached the limits of their technical-industrial prowess. Nor are they swallowing their pride. Times are hard, they said. It's just a matter of money.

—Joshua Jampol

Update

GAS Prices Up

Citing inflation, NASA has boosted the ticket price for small canister-enclosed experiments in need of a ride on the shuttle ("Get Away Special," February/March 1988). The price of a 60-pound canister is now $8,000, up from $3,000; a 200-pound canister will cost $27,000 rather than $10,000. The Get Away Special program is geared toward the educational community. Robert Tucker, director of the agency's space transportation services, says the price is still "a tremendous bargain."

Exhibits Central

CAROLYN RUSS

The folks in the exhibits department work behind the scenes to bring the Museum to life.

They just finished working on the National Air and Space Museum's new gallery, "Legend, Memory, and the Great War in the Air" (see In the Museum, October/November 1991). Still on the boards are a new gallery illustrating the principles of flight, the new "Where Next, Columbus?" quincentenary gallery, and others on the Vietnam War, Star Trek, the planets, and cosmology—to list only some. Never in recent memory has the Museum's department of exhibits had so many new projects on its plate at once.

Exhibits may start as ideas, but the ideas have to be translated into real materials, images, and displays, and it's at this point that the department's veteran designers, director Nadya Makovenyi, John Clendening, Lou Lomax, and Terezia Takacs, suit up. If the Museum's exhibits committee determines that a gallery idea has merit, cost estimates are drawn up, together with a preliminary look at the impact a new gallery will have on the rest of the Museum. Once the formal go-ahead is given, curators and designers convene, set a schedule for completion, and start a concept script. The cycle of planning for a major gallery can take as long as three years. But, the designers caution, there's no such thing as a "typical" gallery.

Designers like to think they come to the table as advocates for the visitor, who will see only the final result of their work. Makovenyi describes the job as "millions of little things"; Takacs wonders whether "they think we just sit in an office and pick nice colors." Lomax adds, "Yes, and the rest somehow just happens."

As a new gallery takes shape, the designer can be tugged in different directions by a number of competing considerations. "Right now, due to the state of the economy, funding is a consideration," says Makovenyi. "Computers and interactives [exhibits that visitors can manipulate] are big line items that cost the most money. So you look at those items. It requires you to be more imaginative." A recently completed gallery devoted to the role of computers in aeronautics and astronautics, "Beyond the Limits," is loaded with electronics and computerized exhibitry that allow visitors to perform such tricks as flying a P-51 fighter and designing and launching a multi-stage rocket. It was also the first gallery with a budget that topped $1 million.

Together, the four Museum staffers have a total of 120 career years with the Smithsonian Institution. Takacs left Hungary while still a student in the wake of the 1956 revolution there, worked in the United States as an illustrator "until my English got better," then joined the Smithsonian in 1963 after becoming a U.S. citizen. Her definition of a good designer: "Someone with a good imagination, a sense of feeling for spaces and arrangements, composition, and an understanding of how to translate a script into something visual."

Lomax studied architecture at Howard University in Washington, D.C., before starting his career at the Museum of Natural History in 1959. To him, the challenges of designing museum exhibits are "to get along with an awful lot of people, to zero in on an idea quickly, [and to] relate to the public. It's hard to do."

Clendening, who considers himself a painter rather than a designer, still makes time to paint every day. A graduate of Washington's Corcoran School of Art, he joined the staff at the Museum of American History in 1960. "Design has two functions," he says, "the architectural and the graphic. You need a good sense of both of those to succeed."

Makovenyi came to the Smithsonian in 1960 as a graduate of George Washington University and became head of her department in 1984. She sees the designer as "the constant. Each [gallery] has all new players. You're the one who guides, who adjusts to their work habits." It also helps to get some shut-eye, she says. "You get a lot done while you're sleeping. I'll hit a stumbling block, and in the middle of the night an idea comes. I've never been dumbfounded. I've always found answers."

With all the new galleries on the docket, she'll need her rest.

—George C. Larson

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Indoor Stargazing

Pay no attention to the man behind the curtain at the Museum's Albert Einstein Planetarium. His name is Dalton McIntosh and, like the Wizard of Oz, the audiovisual technician performs visual trickery while hidden from view. His repertoire, however, leans toward violent supernovas, black holes, and a starry night sky.

All of the above are included in "Exploring New Worlds," the latest offering from the planetarium. Inspired by the 500th anniversary of Columbus' voyage, the new show focuses on the human drive to explore. It surveys 30 centuries of exploration and includes an itinerary that ranges from the *Titanic* at the bottom of the ocean to Venus during the Magellan probe's flyby.

"Exploring New Worlds" also demonstrates how far planetariums have evolved since the days when they offered a backyard tour of the night sky. In a narrow corridor behind the planetarium nearly 400 projectors stand ready to transform the planetarium's dome into almost any cosmic phenomenon. "With all our wonderful new special effects equipment and computers and so on, still I think the best special effect we have is the starry sky," says planetarium director Jim Sharp.

It's no coincidence that the new show

GEOFF CHESTER

includes the planetarium director's all-time favorite celestial object: a young star cluster called M16. "It looks like the gown of an angel," he says. His least favorite objects also appear, unfortunately, throughout the show near the horizon, spelling out E-X-I-T in orange lights. "It's been a nemesis all my life," laments Sharp about the signs.

The exit signs are only a minor distraction, though, compared with the light pollution that nowadays is almost everywhere except for remote national parks in the west. "It's kind of sad," says Sharp, "but it may be that the planetarium is one of the few places now that you can really see the night sky."

—*David Savold*

Museum Calendar

Except where noted, no tickets or reservations are required. To find out more, call Smithsonian Information at (202) 357-2700.

Museum Hours Most Smithsonian museums are open 10 a.m. to 5:30 p.m. daily.

New Exhibit "Star Trek." This major retrospective exhibit will include costumes and props and will feature TV episodes. Opens February 28 in Flight and the Arts gallery.

Choral Concert U.S. Air Force Academy Choir. Milestones of Flight gallery, February 17, noon.

Space Fiction Film Series "Salute to Star Trek 25th Anniversary." Motion pictures, television episodes, and lectures. Langley Theater, every Friday through February 28, 8 p.m.

February 1 Monthly Sky Lecture: "Venus From the Ground Up." Robert Craddock and Jeffrey Goldstein, NASM. Einstein Planetarium, 9:30 a.m.

February 4 Wernher von Braun Memorial Lecture: "American Space Policy: Where Next?" Norman R. Augustine, Chairman and CEO, Martin Marietta. Langley Theater, 8 p.m.

February 6 General Electric Aviation Lecture: "Air Traffic Control in the 21st Century." Joseph Del Balzo, FAA. Langley Theater, 7:30 p.m.

February 10 Black History Month Lecture: "A Black American's Experience in Aviation." Neal Loving, Wayne School of Aeronautics. Langley Theater, 7:30 p.m.

February 11 Exploring Space Lecture Series: "American Astronomy Before Columbus." John Carlson, University of Maryland. Einstein Planetarium, 7:30 p.m.

February 20 Black History Month Lecture: "Benjamin O. Davis, American." Benjamin O. Davis, USAF (ret.). Langley Theater, 7:30 p.m.

March 5 General Electric Aviation Lecture: "To Fly and To Fight." Clarence E. "Bud" Anderson, World War II triple ace and USAF test pilot. Langley Theater, 7:30 p.m.

March 7 Monthly Sky Lecture: "Exploring New Worlds." Ellen Sprouls, NASM. Einstein Planetarium, 9:30 a.m.

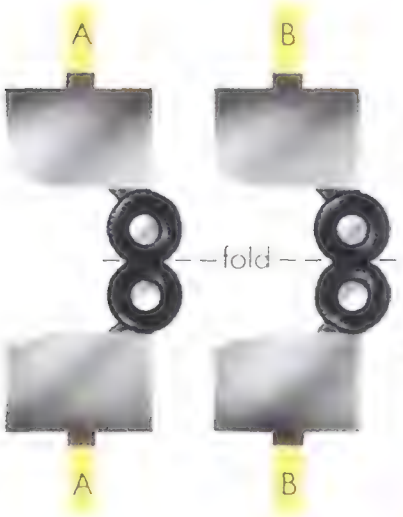
March 11 Exploring Space Lecture Series: "Astronomy From the Bottom of the World." Jim Sweitzer, University of Chicago. Einstein Planetarium, 7:30 p.m.

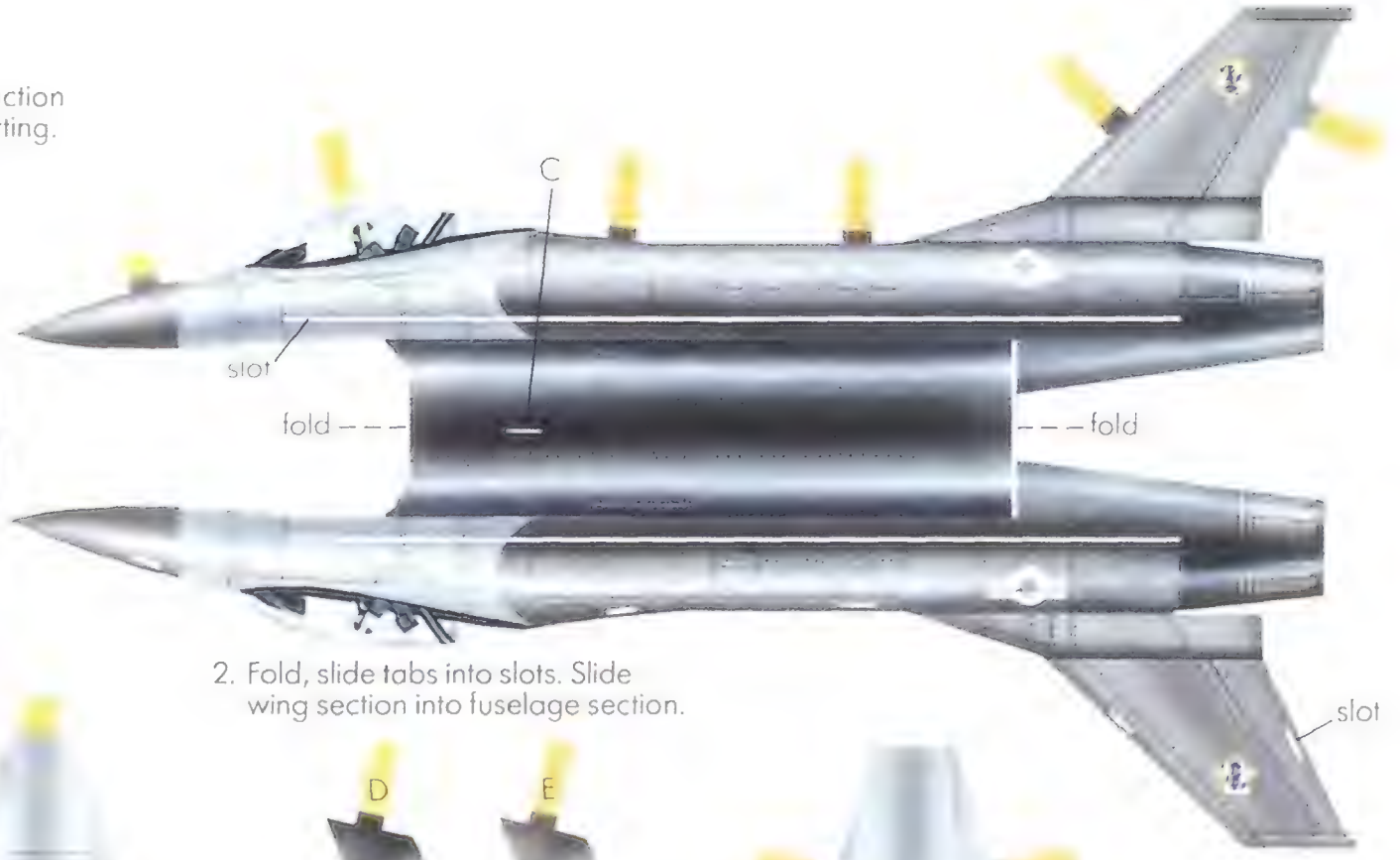
Artifacts

LEE BATTAGLIA

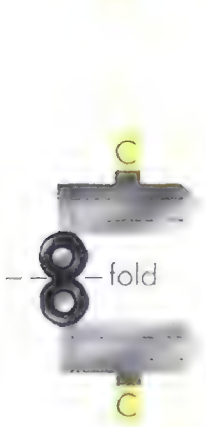
Voyager*'s trip got off to a rough start when the airplane's wingtips scraped the ground during takeoff on December 14, 1986. But when the graphite-honeycomb composite aircraft landed nine days later, it had set a world record by circumnavigating the globe without refueling. Now suspended in the Museum's south lobby,* Voyager *was honored on the fifth anniversary of its historic flight last December, when many of those involved in the effort gathered in Mojave, California, for a commemorative dinner.* Voyager*'s pilot, Dick Rutan, still lectures about the flight and enjoys seeing the airplane in the Museum. "I'm very honored to have it displayed there," he says.*

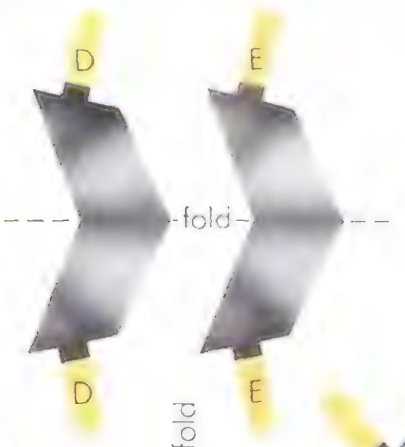
1. Glue page to heavy construction paper and let dry before cutting.





2. Fold, slide tabs into slots. Slide wing section into fuselage section.





3. Insert lettered tabs into matching lettered slots.

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Off the Record

When I was a young woman back in the 1930s, we got the news not through television broadcasts but through newspaper reports. There were more readers, and there were also more newspapers. So many papers, in fact, were competing for the same audience that newsmen would do just about anything to beat the other guy, often writing stories long on exaggeration and short on truth. Of course we in the budding aviation industry were only too happy to cooperate by feeding the press stories on a daily basis. We needed the publicity to attract financial backers and they needed good stories to sell newspapers.

We had a give-and-take relationship, but at times I found myself exasperated by the reporting. We pilots were all labeled "intrepid birdmen"—or -women—and we were all so darned brave and daring that it's a wonder we deigned to associate with ordinary folks at all. I was commonly described as "plucky Elinor," "Long Island's flapper flier," or simply "girl flier." Otherwise, the press usually treated me fairly. Nonetheless, some of the stories still make me wince. The most mortifying coverage came when I attempted to set the women's altitude record in 1931.

On a brisk March day, I took off from New York's Roosevelt Field. I was working for airplane designer Giuseppe M. Bellanca, and with any luck I'd reach 35,000 feet and bolster his contention that passenger carriers would soon operate safely above the weather. When I reached 25,000 feet I looked down on the city of New York and saw a fairy kingdom: spires glistening in a sun that turned the city's rivers into ribbons of gold.

My airplane, a Bellanca Skyrocket powered by a supercharged 575-horsepower Pratt & Whitney engine, was larger and heavier than anything I'd flown before. But from the first time I'd flown her, she proved to be a user-friendly craft of the highest quality. That took care of the positives. Now for the negatives: Cabin pressurization? Not even a gleam in an engineer's eye. Backup hydraulics? I was my own backup and hydraulics was only a word in the dictionary. Lubrication? Every drop of oil had been wiped from the controls to prevent them from freezing in a position I couldn't get them out of. Ice in the carburetor? Not if the new heater lived up to its billing.

Which leaves us with the oxygen equipment. When I tested it on the ground, I found you needed the lungs of a glassblower to activate the valve that controlled airflow. This sent the Navy engineers who designed it back to the drawing board. They came up with an oxygen bottle, actually a lead-encased container that I wore around my neck on a leather thong, clenching my teeth around its rubber tubing and taking a breath whenever I thought I needed one. This primitive contraption had one big drawback: there was no way to tell when you had emptied it. Oh well, you can't have everything, and this was a lot easier on the lungs than the first design. My altitude attempt would be a piece of cake, I thought as I continued to climb.

That hope died when the engine did, the prop arcing slowly to a stop at 26,000 feet. But I wasn't too worried. At that altitude I had a 52-mile gliding range, more than enough to get back over Long Island's open fields. But if I didn't get that engine started up within seconds, the record was out the window. To save weight I'd practically rationed gas with a teaspoon. No way would there be enough fuel to recover altitude and climb back up. So I swung the ship toward the east, jammed my knee against the stick to hold the nose down, leaned toward the instrument panel to jockey the fuel mixture and throttle knobs...and that's the last I remember until from afar I heard the shriek of the wind as it whistled over wings and struts at a pressure they were never designed to withstand. My head felt like a balloon and the altimeter needle was racing around the dial like a scared mouse. Nosing straight down, my 3,000-pound bird was heading for the bottom of the Hempstead Reservoir.

Attempting to halt this wild descent, I

PHOTOS COURTESY ELINOR SMITH

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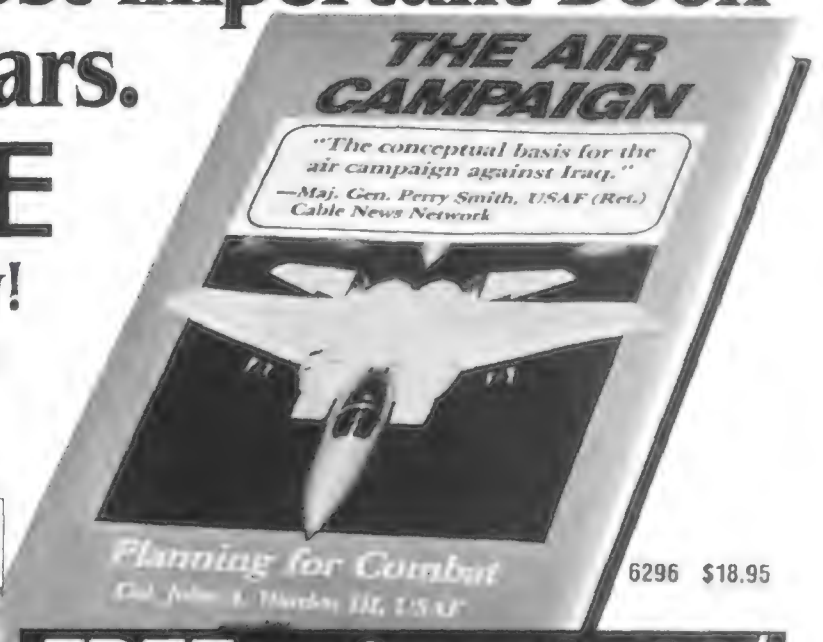

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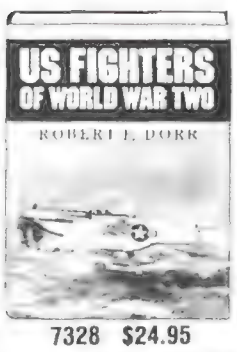

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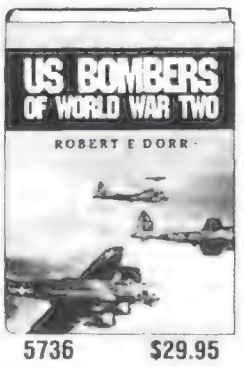

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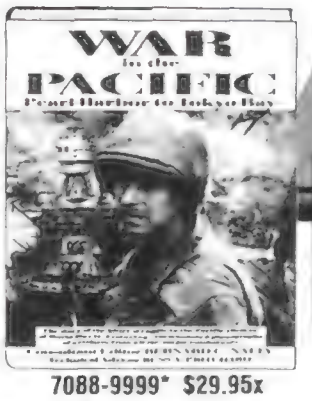

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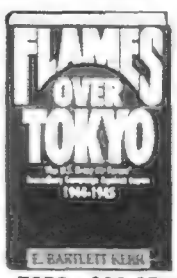

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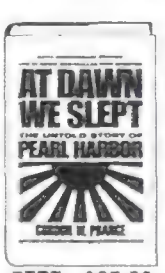

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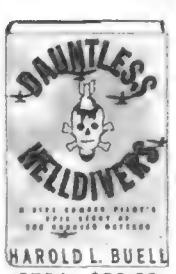

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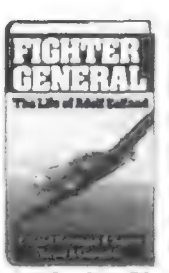

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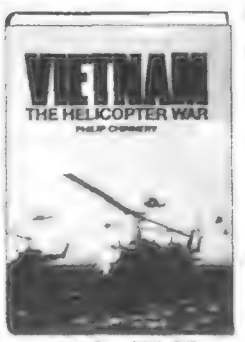

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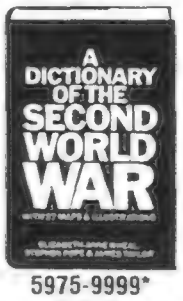

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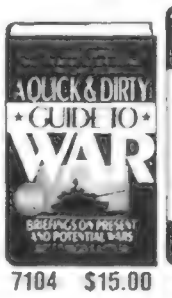

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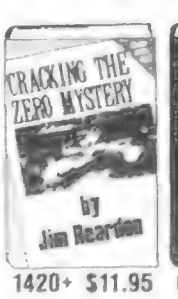

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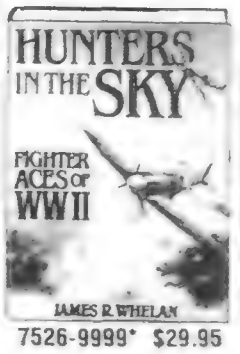

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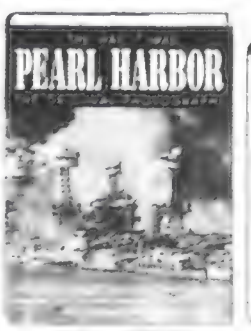

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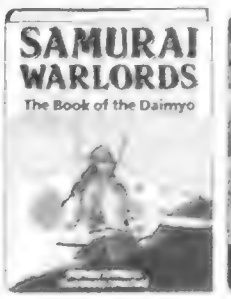

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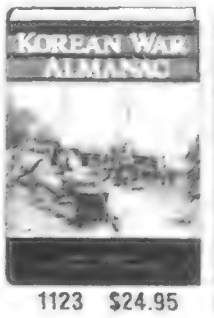

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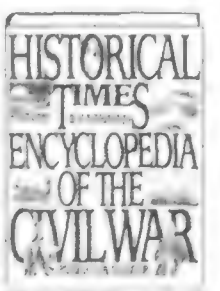

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eased back on the controls and held my breath, terrified that the pressure of straightening out the dive would peel the wings off. True to Bellanca tradition, the wings held, but every foot of lost altitude lessened my chances of getting back to Roosevelt Field—or any open field, for that matter. I knew I'd started the pullout at 6,000 feet. I was probably at a third of that now and would lose more as I raced over the houses of heavily populated Hempstead and the stately mansions and church steeples of Garden City.

Tearing past these imposing homes, I considered making a run for nearby Mitchel Field. Then I remembered the old Camp Mills site. But here my luck really ran out: I'd forgotten that Camp Mills had fallen into the hands of a developer who was covering the former tent city with houses. I saw one very short cleared space, but at the end of it two tall trees stood like sentinels. They were too close together to let more than the ship's fuselage pass through. Ripping the wings off would total the aircraft, which was unthinkable. These ships cost more money than I dared dream about, and besides, I wanted to go up again—soon.

Throwing the ship into a steep sideslip, I decided to land in the clearing anyway and do some fishtailing to cut my speed. Slamming the Skyrocket down into a hard three-point landing, I jammed on the brakes with all my strength. I knew I'd have to turn her over and I prayed that the tail would land between those two unfriendly trees. Fortunately, it did. Since I had cut the ignition and gas, fire was not a problem. My heavy flightsuit and boots cushioned me as I was tossed around.

The upper wing was now under me, and I eased myself over it and walked slowly around my ship. I was elated by what I saw. Other than a bent prop and several broken ribs in the top wing, she would be good as new. But quite suddenly, the bitterness of defeat overcame me. The oxygen bottle, hanging limply on its cord, added the final tragic touch to the story. When I'd leaned toward the instrument panel, the tube must have dropped out of my mouth. This realization brought on a flood of tears that surprised even me.

My brother Joe was first on the scene to oversee the block-and-tackle crew as they righted the big ship. He was soon followed by the usual clutch of reporters and photographers, who always seemed to spring out of the ground. Much to my distress, the photographers waited until my blue and yellow airplane was actually standing on her nose before taking the pictures that would be in all the papers and newsreels that night. A gullible public would assume that she had landed on her nose after a vertical dive of 26,000 feet! If she had, there wouldn't have been enough of the ship—or me—left to photograph. Of course, no mention was made of the fact that there was hardly a scratch on the Skyrocket. Below a photo of my vertically posed airplane, the *Newark Ledger* commented that it was "apparently bound for China after dropping 23,000 feet...."

Hailed by reporters as "Long Island's flapper flier," Smith (above) was distressed by the photograph below, which made her airplane appear to have landed nose first. Inset: The pilot tests her oxygen equipment.

A week later the Navy issued a report on the oxygen equipment. The cylinder had a minute crack, which meant that the oxygen had leaked out before I'd had the chance to use it. But we still weren't sure why the engine quit, so we put in a new one. Ten days later, with a spring-catch on the oxygen line to keep it firmly in my mouth, all the dents in the prop banged out, and six ribs replaced on the top wing, I went up again. This time I hit over 34,800 feet on the altimeter. Of course, this would probably register less on the more sensitive barograph installed by the National Aeronautic Association, which would have to be checked by the Bureau of Standards.

While awaiting the calibration results, Bellanca and I reported a far lower altitude to the newspapers, hoping for a whopping upset in their follow-up stories. We knew we'd brought back an outstanding record. Confirmation of temperatures and wind conditions recorded that day by military weather balloons, along with Pratt & Whitney's engine data, proved that I'd made at least 34,000 feet. Unfortunately, the Bureau of Standards reported that the barograph cylinder had cracked and that the needle had stuck at 28,000 feet, destroying all hope of setting a new world's record.

The newspaper follow-up stories were brief and carried no pictures of my second attempt. But many of the accounts ran alongside the picture from my previous effort: the gallant Bellanca poised on her nose.

—Elinor Smith

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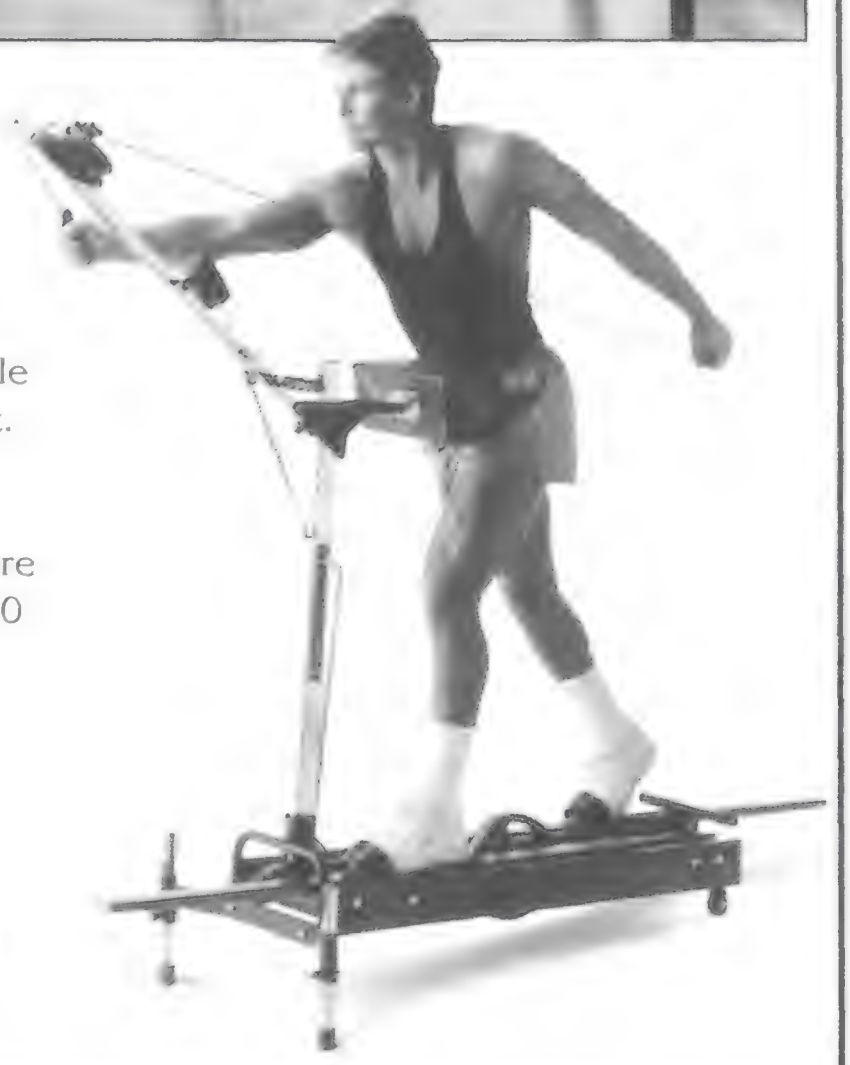

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Dial-a-Planet

In 1989, after a delay of several years, astronauts aboard the shuttle *Atlantis* launched the Galileo planetary probe on a roundabout journey toward Jupiter. Having already cruised by Venus, Earth, and the asteroid belt, Galileo will next return to Earth, then check out an asteroid named Ida, and finally slam-dunk a research probe into Jupiter's atmosphere sometime in 1995. That's if all goes well.

But life's a series of accidents, whether you're talking about the chances of a planetary probe making it to Jupiter after careening around the solar system or, say, the likelihood of a phone call making it from my Manhattan apartment to somewhere in Florida. That's why I believe I could do the same research as the Galileo probe at a fraction of the time and cost. Thus, I, Phil Scott, have created my own planetary research program based on my telephone.

NASA's Galileo planetary exploration craft cost $1.4 billion. I paid $69 for my Radio Shack TAD-252 Duofone dual-microcassette telephone answering system. (To be fair, it retails for $99.) The 5,640-pound Galileo will negotiate 3.8 billion miles of interplanetary space, relay data on the celestial bodies it encounters, and eventually release the probe that will analyze the thick Jovian atmosphere. The three-pound TAD-252, according to the owner's manual, can call just about anywhere in the world, redial numbers automatically, and record messages and conversations on microcassette. The TAD-252's size-to-capability ratio being about equal to that of Galileo, Phil's Aeronautics and Space Administration gave the phone probe the nod to embark on an exploration of the solar system after breakfast one recent morning.

First stop: Venus. After consulting the atlas, my mission research team located Venus in the southern tip of Florida. Mission Control picked up the TAD-252 transceiver and dialed.

Mary Worley, who works in the water department of Venus' nearest neighbor, Lake Placid, said, "There's really nothing down there but farms and a post office." Undaunted, Mission Control maneuvered for a closer look. Suzanne Armand, Venus postmaster, described the environs as inhabited, albeit sparsely—she estimated the population to be roughly 750—and large. "Our postal carrier can drive up to 100 miles a day," she said. The climate is warm—in the mid-80s Fahrenheit—with a fair amount of precipitation, which enables the inhabitants, who live on large ranches, to grow citrus fruit for survival.

After our brief examination of Venus (and learning that the inhabitants refer to themselves as "people from Venus" rather than "Venusians"), the TAD-252 maneuvered for a flyby of Earth, located in west Texas. Mission Control first contacted one of Earth's closest neighbors, Plainview. Phillip Hamilton, a reporter for the *Plainview Daily Herald,* has actually seen Earth close up. His report not only astounded every scientist here at Mission Control, it promises to rewrite the astronomy books.

Earth, Hamilton observed, is as flat as day-old beer. "It's a one-stop-sign place whose claim to fame is a Dairy Queen commercial filmed at the DQ there a couple of years ago." Hamilton said most of the inhabitants are pretty friendly, but cautioned that they take umbrage at phrases like "Greetings, Earthlings."

We maneuvered closer. Speaking with Christy Clark, an Earth-based postal clerk, we were able to confirm that Earth is indeed flat, though it has some sandy rises. We told Clark that our research team had studied Earth's long history of warfare and pollution. Flabbergasted, she said, "There's no pollution here, and everyone is friendly and nice." Clark admitted that many people steal the "Welcome to Earth, Population 1,512" signs, but the thieves are mostly aliens—college kids, to be exact. She also advised that Earth residents are constantly teased by outsiders. "When you say to someone, 'I'm from Earth,' they'll say, 'Yeah? Well, I'm from Mars.' "

Lacking the fuel to make it to the asteroid belt, Mission Control next homed in on Ida, which resides in the Sun Belt (specifically, Louisiana). We spoke to Sid A. Dean, mayor of Ida—population 306—for 25 years. Dean confirmed that Ida was indeed rocky, but he added that it was mostly hilly. "I guess you know we just got through with an election down here," he said. "My man won. But people all over are going to have to worry about that stuff from now on."

Thus cautioned, Mission Control zeroed in on its final destination. Little the worse for wear—as well as on time and under budget, I might add—our tiny probe arrived at Jupiter as the day ended. Speaking with Carol Cingle of the Jupiter, Florida Chamber of Commerce, I asked the question that scientists have pondered for decades and that the Galileo probe is supposed to answer: What makes up the atmosphere of Jupiter?

There was no answer for a moment, probably due to the great distance between Jupiter and Mission Control. Then came a response. "Well, it's kind of quiet here," she said. I asked, "What can humanity learn from Jupiter?"

"I have some brochures," she said. "Let me send you what I have."

—Phil Scott

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Rescue From Above

When an airplane goes down, the pilot can't call 911.

Photographs by Chad Slattery

by Breck Henderson

Troy Arce was on his way to a Saudi Arabian air base one night during the Gulf War when his helicopter was abruptly ordered to divert into Iraq—an F-16 piloted by Air Force major Jeffrey S. Tice had been shot down. Tice's wingman had stuck around as long as he could, but only Arce's helicopter and its crew could save the downed pilot from capture.

The 28-year-old Arce, who works full time for the Air National Guard at Moffett Field, California, is a pararescue-

The herald of deliverance for downed pilots, a Sikorsky Pave Hawk comes in for a landing during a training mission (left). Later that day, pararescuemen undergo a surprise drill in first aid technique (below).

man, one of eight who were sent to the Gulf to assist the 1723rd Special Tactics Squadron in search-and-rescue missions. As handy with a parachute as he is with an I.V. unit, Arce can not only rescue pilots but keep them alive until they can be flown to a hospital.

The Sikorsky MH-53J Pave Low helicopter flew low and fast over the dark Iraqi desert completely blacked out, its aircrew wearing night vision goggles that made the terrain look green. The aircrew tried to make radio contact with Tice but got no response. "A lot of things went through our mind at the time," says Arce. "We didn't know whether he was captured, whether he was killed. We were thinking: Well, what is he thinking? Is he thinking that we're the enemy looking for him and he's just not going to talk because he's afraid that he'll be compromised and captured?"

After nearly three hours of searching, the crew received word that their helicopter had been detected by the Iraqis, "so we kinda made a beeline back for the border," says Arce. "It just wasn't a classic good-luck rescue, you know, where everything comes into play and he does everything he's supposed to do and he's picked up and everyone's happy. It just wasn't one of those missions. We heard his name on CNN two days later so we knew he'd been picked up [by Iraqi forces]. It was an awful feeling."

For Arce, it was especially frustrating not to be able to use the special com-

Since pararescue work often involves water operations, a PJ's swimming ability must match his parachuting skills. Training with the Coast Guard, PJs rescued the crew of a burning boat (above) and were then plucked out of the San Francisco Bay (right).

bination of skills that he has spent years developing. Though an air combat rescue team consists of pilots, flight engineers, and radio operators, the most dramatic role is played by pararescuemen, better known as PJs (short for "parachute jumpers").

PJs can parachute day or night and land safely on surfaces ranging from ocean to forest. They can swim or dive to reach a downed pilot and render lifesaving medical care. Trained to survive in almost any situation, PJs can fight their way out of trouble if attacked on the ground behind enemy lines.

A career as a PJ isn't for the faint of heart. Chief Master Sergeant Steven D. Wofford, the pararescue superintendent of the California Air National Guard's 129th Air Rescue Squadron at Moffett Field Naval Air Station in California, says that the washout rate for aspiring PJs is 90 percent. "The Air Force can afford to be selective because there are so few of us—just 280," he says. About 90 of those are in the Air National Guard, 90 more are in the Air Force Reserve, and the rest are on active duty. "We get guys who are good athletes, or interested in medicine," says Wofford. "It takes someone who is bright, but also someone who is independent by nature." Much of a PJ's work is done alone or in small teams behind enemy lines. (Since the job of pararescueman is classified as a combat position, there are no female PJs.)

Training begins with eight weeks at what Wofford calls "Superman University," a pararescue program at Lackland Air Force Base near San Antonio, Texas. Prospective PJs rise at 5:00 a.m. for three hours of calisthenics, followed by a couple of hours of cross-country running and an afternoon of swimming.

Mental drills on medical terminology or other specialized knowledge break up the physical activity, and all is accompanied by harassment from instructors, who try to induce the stress of combat. "Take Marine Corps boot camp and magnify it a couple of times and you get an idea of the kind of stress these guys are placed under," says Wofford. "It's the only way we can weed them out."

Those who survive Superman U. go on to scuba school, static-line jump school, survival training, and free-fall jump school. They receive a final 21-week course in medicine, ground operations, weapons training, and aircrew training at the PJs' home at Kirtland Air Force Base in New Mexico. "This is where we lose the next largest group," says Wofford.

The medical skills PJs learn at Kirtland are similar to a paramedic's, but PJs do surgical procedures that no paramedic is allowed to attempt. "We're on our own when we work," Wofford says. "We make our own diagnosis, we call our own shots. We can perform intravenous therapy and even do amputations if necessary."

After medical training, PJs improve their parachuting skills by learning how to jump in the worst possible conditions: with a full set of scuba gear, with packs and weapons, and into trees. Night jumps become routine. But danger is always there: no matter how well trained, PJs inevitably suffer injuries or worse. "You know, I hate to say it, but we average one or two [fatalities] a year," says Wofford. When asked about the fear factor, Wofford says, "I guess you break it down into maintaining control, analyzing the risk, take action. Yeah, any time that you go and jump out of an aircraft there's an apprehension factor. We don't like to use the word 'fear,' but there's an apprehension factor and if it wasn't there then I think you'd be in trouble.

"I'm 40 years old and I'm a dinosaur in this business," says Wofford, who has been a PJ for 21 years. He has twice broken his back and has withstood numerous less serious injuries, but he says he has no regrets. "My life is a dream. I ski, I dive, I parachute—I get to experience things that others pay a lot of money for, and along the way I've helped a lot of folks stay alive. It's challenging, and PJs probably get into it first because of the macho image. But after a while, after all the shine and luster leaves, they stay with it because they feel they are contributing something."

After more than a year of training, a graduate PJ is qualified to wear a distinctive maroon beret and join a pararescue team as a "3-level" PJ, the lowest level in the Air Force specialty code system.

During the Desert Storm offensive, members of the 129th were put on alert in Iceland to replace rescue workers sent to the Gulf. When not painting their noses blue to mark crossing the Arctic Circle (right), PJs and aircrew ran refueling exercises (below).

"Then they start all over again with training to be a team member that lasts another six months," says Wofford. "They have to learn what the real world is like." Because the range of required skills is so extensive, it usually takes a PJ four years to become a fully productive team member.

For those PJs who are regular members of the national guard, the obligation calls for more than the usual one weekend a month. "We can't do what we have to do in just one weekend a month—it's impossible," says Staff Sergeant Matt Wallace, who comes to Moffett at least four extra days a month to practice PJ skills. For Wallace, the tough training and the time away from

HC-130s do double duty for the 129th: not only do they refuel helicopters, they also transport PJs and medical equipment to rescue sites.

family and job have become too burdensome, so he plans to let his enlistment expire. He is leaving a little sooner than average. "Usually around the 12-year point, they start looking for something else," Wofford says. Injuries slow some. Wives concerned about the danger persuade others to stop.

Wofford, who has been married since he was 18, says, "I think that this business puts a tremendous strain upon that kind of relationship because we're gone all the time. In the old days most PJs were married two or three times. When you're in helicopter crashes or you break something and you're in a hospital, it takes a toll on a woman and she has a tendency to start to separate herself from you because she's got to hide herself from that pain. What my wife does—at least she tells me—is she puts it totally out of her mind what it is that I do. Maybe it's like being a cop's wife."

As a supervisor of younger PJs, Wofford encourages family participation by planning gatherings and sending cards each year to the wives expressing his gratitude for their sacrifice. But still, he says, PJs "live life to the fullest, so I don't know if that's real conducive to marriage relationships anyway."

Last June, the 129th Air Rescue Squadron spent a weekend training in the scenic Coast Range of northern California. The campsite, a 40-acre patch of pasture dotted with tents at one end, was surrounded by steep green mountains. The south fork of the Trinity River flowed nearby.

As the sun crept over the ridge to the east, throwing warm patches of gold on the floor of the little valley, men and women in green flightsuits and Air Force camouflage uniforms popped out of their tents to start the day. Many of them walked down past an apple orchard to the other end of the pasture, where they worked on four camouflage-painted helicopters.

At 7:45 a.m. the intelligence officer, Captain Catherine Ederington, briefed members of the 129th on a simulated mission: they would deploy in territory replicating a mountainous region

near Bogota, Colombia, known to be a base for drug cartels. A four-man aircrew was down and trying to evade capture by the cartel's armed squads. Army units in the same area had captured one of the drug lords and they too had to be taken out.

A few minutes later, the whine of a turbine engine started up, followed by the steady beat of rotors as the four HH-60G Pave Hawk helicopters, specially configured variants of the Sikorsky Black Hawk, warmed up, their downwash flinging bits of grass and dust into the air.

Aboard the helicopters, pilots methodically went through each item on the takeoff checklist over their intercoms. After a careful check outside to ensure that his flight path was clear, one of the pilots lifted his helicopter to a hover, then maneuvered to the middle of the valley. The helicopter climbed effortlessly toward a small patch of sky, green mountain walls falling away rapidly until it drew even with the ridgetops and banked steeply to the south.

The day before, the men from the 129th who had been tapped to play the survivors had arrived at a point 85 miles south of the cool mountain campsite. They sought shelter from the hot sun in the paltry shade of small trees and manzanita brush.

The survivors took inventory of their equipment as flies buzzed around them. Master Sergeant Louis Hernandez and Staff Sergeant Reed Johnston, survival specialists with the 129th, were along to provide training. Their first lesson: aircrews who suddenly find themselves on the ground have to do more than lie around waiting for rescue. "If a pilot on the ground doesn't do anything, he won't make it," said Hernandez. The crew must work as a team, survive harsh conditions, navigate rough terrain to arrive at the pickup site on time, and properly signal their rescuers.

The first priority is taking care of injuries, followed closely by finding shelter and devising a plan that will conclude with a successful rescue. All pilots carry a survival vest equipped with a radio, signal mirror, compass, and a small plastic-coated Air Force survival manual. Other items must be taken from the aircraft: clothing, food, water, and essentials like cord and maps. The next task is to determine precise location, which is not easy. A pilot may know generally where he was flying when he went down, but the terrain features must be matched more exactly with maps to get a fix to start moving by.

Survivors, the enemy, and the rescuers often play a three-way cat-and-

Current law says a woman can't be a PJ, which is classified as a combat position. But women can support rescue work by managing intelligence and flight operations.

mouse game. Somehow the pilot must make his position known to his rescuer without giving it away to the enemy.

A Desert Storm rescue illustrates just what a survivor may have to do to elude capture. The pilot of an F/A-18, after parachuting safely to the ground when his jet was hit by enemy fire, walked quickly off in one direction, then backtracked, leaving a dead-end trail while he ran in another direction for several hours. Then he hid out for a day. Only after he sensed that the Iraqis had given up looking for him did he signal his rescuers with his position. "The guy obviously had a plan and had thought it through before he ever hit the ground," Hernandez observed.

When the rescuers talk by radio, they have to be sure that they are talking to the survivors and not being lured into a trap by the enemy, a common deception in Vietnam. A little planning can reduce the danger. Each person on an

aircraft flying in hostile territory leaves behind an authentication profile, describing a favorite car, baseball team, or first girlfriend, with a few details that only he would know. Rescuers will not approach unless the survivor can correctly answer questions drawn from the profile.

After an hour spent organizing their gear into packs and determining where they were and where the pickup zone was, the four men playing the downed crewmen set off through ten-foot brush for a rendezvous with the group assuming the role of special forces soldiers (actually PJs who parachuted down later in the afternoon). Before the entire group could be extracted, they had to survive the night on the ground.

About 650 miles off the coast of California that same day, PJs were on their way to the victim of a real-life accident. An engine room mishap had badly burned a Philippine crewman aboard the Liberian cargo ship *Gemini*. Coast Guard helicopters cannot range that far out, so the 129th, which operates HC-130 tankers to refuel its HH-60 helicopters, was asked to help. (During peacetime, most of the 129th's rescues are of this type. "That's one thing I'm most proud of," Wofford says. "Taxpayers get their money's worth from us in peace or war, and that's significant. Those helicopters pay for themselves this way.")

Two PJs participating in the training mission, Senior Master Sergeant Alan Manuel and Sergeant Leif Eiriksson, were chosen to make the real rescue. After reconfiguring for two hours, they flew out in an HC-130 tanker and parachuted into the sea just ahead of the ship. By the time their equipment was dropped, the sun was setting. The waves were 15 to 25 feet high, but fortunately they weren't breaking yet. If they had been, "the only thing you can think of is getting your next breath of air," says the 26-year-old Eiriksson.

The freighter sent out a small boat to pick them up, but things didn't go smoothly because the crew spoke no English. "One of the Philippinos borrowed my knife," says Eiriksson. "I thought he was going to cut the parachute away, but he cut the bundle apart. I had to jump back in the ocean and collect my gear as it was drifting away. I ended up doing that three times before I got all the gear."

Halina Monczyn, who tracks flight operations, holds one of several life rings from ships assisted by the 129th.

PJ Tim Young makes weekly trips to the weight room to maintain the top physical condition his job requires.

An hour after they had jumped from the HC-130, Manuel and Eiriksson were taken aboard the cargo ship. There they set up a small field clinic. The seaman, whose legs and back had been burned when a steam line ruptured, was in bad shape. Gauze wrapped around his swollen legs was cutting off the circulation. "I think it took me four to five hours to cut and remove the outer layer of his skin along with the gauze, just taking it one inch at a time," says Eiriksson. "We had him drugged up pretty heavy on morphine. Had I.V.'s with antibiotics running all night."

At dawn Eiriksson had a crewman take him up to the foredeck so he could plan for a helicopter extraction. Dismayed by the rough seas and the sight of water washing over the deck, he and Manuel tried to call off the extraction mission, but the rescue helicopter had already departed from California. Fortunately, the captain was able to head the ship into the wind, preventing the sea from washing over a rear hatch they could use for the rescue.

After the injured seaman's litter was hoisted up and aboard, Manuel and Eiriksson accompanied the sailor to a San Francisco hospital. The rest of the helicopter crew returned to camp, where a pickup truck awaited them.

On its way to the command tent, the pickup stopped near a fire truck. As the weary crew sat in the back of the pickup, a fire hose suddenly blasted them

It's taken years of practice, but pararescue veteran Lou Haack has mastered the many tools of the trade.

with a stream of cold water and then the rest of the 129th rushed out to douse them with beer. Such highjinks are the traditional welcome for a crew returning from a successful mission. "It's kind of the old 'You work hard, you play hard,' " says Wofford.

Earlier that day, two helicopters had raced toward the pickup site to rescue the downed aircrew of the "Colombia" mission. Intelligence had plotted them a course to help steer clear of areas where the drug cartels were said to have arms or Stinger missiles. To conceal themselves, the helicopters stayed low. In the mountains, helicopters can fly below the ridgetops to avoid radar. The PJs say a low-flying Black Hawk can't be heard until it's less than a mile away, so moving at 120 mph, it can pass by before anyone can react.

The lead helicopter was just a speck against the mountains, and it took some effort for the second pilot to keep it in sight. The two helo pilots worked together, watching for power lines and other aircraft. With the helicopters often flying just a few hundred feet above the trees, the feel of the wind rushing by the windows evoked the age of open cockpits.

With all the zigzagging, it took about an hour to reach the pickup zone. Technical Sergeant Sean Casey pondered the condition of the survivors and worked out a plan to remain on the ground in case it got too hot for the helicopters to stick around. "We can survive for 30 days with what we have with us," he told the helo pilots, "so don't be afraid to leave us if you have to."

Though all they really needed was a hot shower and some sleep, the four men were eager to be rescued after a chilly night spent evading capture. One helicopter ran low on fuel and diverted to a nearby airport, so the mission had to be completed by the second aircraft—a contingency that was planned for, though it meant jamming in 11 people and their gear.

As the helicopter got close to the pickup zone, someone on the ground with a heavy Spanish accent tried to lure the crew to the wrong point, but the authentication procedures worked and they located the right people. The helicopter dashed in and came to a hover, and the PJs rapidly slid down braided ropes, their hands protected by thick gloves.

Rising higher, the helicopter flew tight turns over the landing zone while the team secured the area and organized the survivors. Then the helicopter landed and everyone clambered aboard for the flight home.

Back at camp, word spread that the helicopter was five minutes out. The players in the next bit of training assumed their positions. As the helicopter arrived, the men aboard encountered a scene that had changed since the morning.

Bodies were now scattered about, the result of an "explosion." The "victims," some with grotesque injuries simulated by strap-on rubber wounds, had to be examined carefully. One was dead, but others were seriously hurt and needed immediate attention. Hauling heavy packs and weapons from the helicopter, the PJs began ministering to the wounded. Litters were soon rigged, the injured evacuated. It had been a long day, but the PJs performed well.

The day ended with a rowdy game of volleyball. Fatigue seemed to melt away as the PJs, aircrew, and support teams plunged into the competition, playing until the sun fell below the mountain walls. Then, after a spell around the campfire, it was time to call it a day. Even graduates of Superman University need their sleep.

SCOTT ANDREWS

By the time a shuttle lifts off from Florida's Kennedy Space Center (above), a NASA team in the Gambia has spent a week preparing an optional landing site. Pre-flight operations include setting up the shuttle orbiter arresting system, a 29-foot-high nylon net (right).

THE SPACE SHUTTLE'S EMERGENCY LANDING STRIP BRINGS THE SPACE AGE TO THE GAMBIA.

IN CASE OF EMERGENCY, LAND AT

by Beth Dickey *Photographs by Mark S. Wexler*

BANJUL

"Ning kewo taata karoo to," says Peace Corps volunteer John Devine as he introduces NASA astronaut David Walker to a group of Gambian villagers. "The only way I know to say 'space,' " Devine confides in English to the astronaut, "is to say 'This man went to the area of the moon.' " Disbelieving stares indicate that something must have been lost in the translation, and Devine shrugs apologetically. "This is tough to explain in Mandinka," he says.

Devine and Walker have traveled 40 miles upriver in the west African nation of the Gambia on a cultural exchange mission at the invitation of the U.S. ambassador. Yet

U.S. Air Force technician David Romero checks a weather balloon at Banjul International Airport (right). The balloons are released on launch day to measure upper-wind velocities.

Prior to a simulation of an emergency shuttle landing, Lockheed's Bill Williams briefs the team. Such practice helps the team avoid the "Gambian Anomaly."

even with photos of shuttle launches and a comical repertoire of sweeping hand gestures and *vrooming* noises, Walker fails to convey his message to many of the residents of the village of Kandonku. *"Mool do mang lawalaa bari nte lawalaata,"* says a school-age boy. From his tone it's easy to guess the meaning of his words: "Many people here don't believe anyone can fly in space."

Understandably, the Space Age makes little sense to most people of the Gambia, a tiny republic of farmers and fishermen that is one of the most impoverished countries in the world. A former British colony, the Gambia is smaller than Connecticut and, except for a 30-mile-wide stretch of Atlantic coastline, is surrounded on all sides by Senegal. The Gambia River extends 450 miles through the country's interior, where crocodiles rule the jungle at the water's edge and monkeys roam the savannahs.

Banjul, the capital, is a city of 46,000 where cars share unpaved roads with cattle. The city's smog mixes with the odors of perspiration, diesel exhaust, open sewers, rotting roadkill, and burning fields. It seems unlikely that the Gambia could play a role in the U.S. space shuttle program, but it has one vitally useful attribute: location. The country "just happens to be geographically located so that any shuttle launched on a 28-degree azimuth—that's straight east out of Florida—crosses right over Banjul," explains NASA's astronaut candidate manager Bud Ream. "They don't have to make any powered cross-range corrections—that's left or right turns—to get there."

In other words, the Gambia is a perfect location to provide an emergency landing site for any shuttle that can't reach orbit because of an engine failure, cabin leak, or other serious problem. In such an event, an orbiter would have to make what NASA calls a Transoceanic Abort Landing. A landing site on the other side of the Atlantic is a backup for an orbiter that can't make a safe return to the launch site and doesn't have the option of making a single orbit and touching down at California's Edwards Air Force Base. The window of opportunity for a TAL is open for about six minutes—from about two minutes after liftoff until about eight minutes into the flight, when the main engines are cut off. "It's a long eight and a half minutes," says Air Force major Tom Appolloni, the Department of Defense coordinator for the TAL team in the Gambia. "You're just seeing how much time is left in your window before MECO [main engine cutoff]."

To date, a shuttle's main engine has shut down early only once. In July 1985

Challenger limped safely into orbit with only two of its three engines operating. Yet NASA has had TAL sites in Dakar, Senegal, and at Spain's Zaragoza Air Base since 1983. A year later the agency added Moron Air Base in Spain, and in 1986 Dakar's TAL site was replaced by Ben Guerir Air Base in Morocco. In 1987 Banjul became the newest TAL site. All four locations were selected because of their proximity to the orbiter's ground track. During a shuttle launch three of the four sites become operational and the one closest to the mission's flight path is designated prime. Weather conditions at the time of launch dictate which site would actually be used.

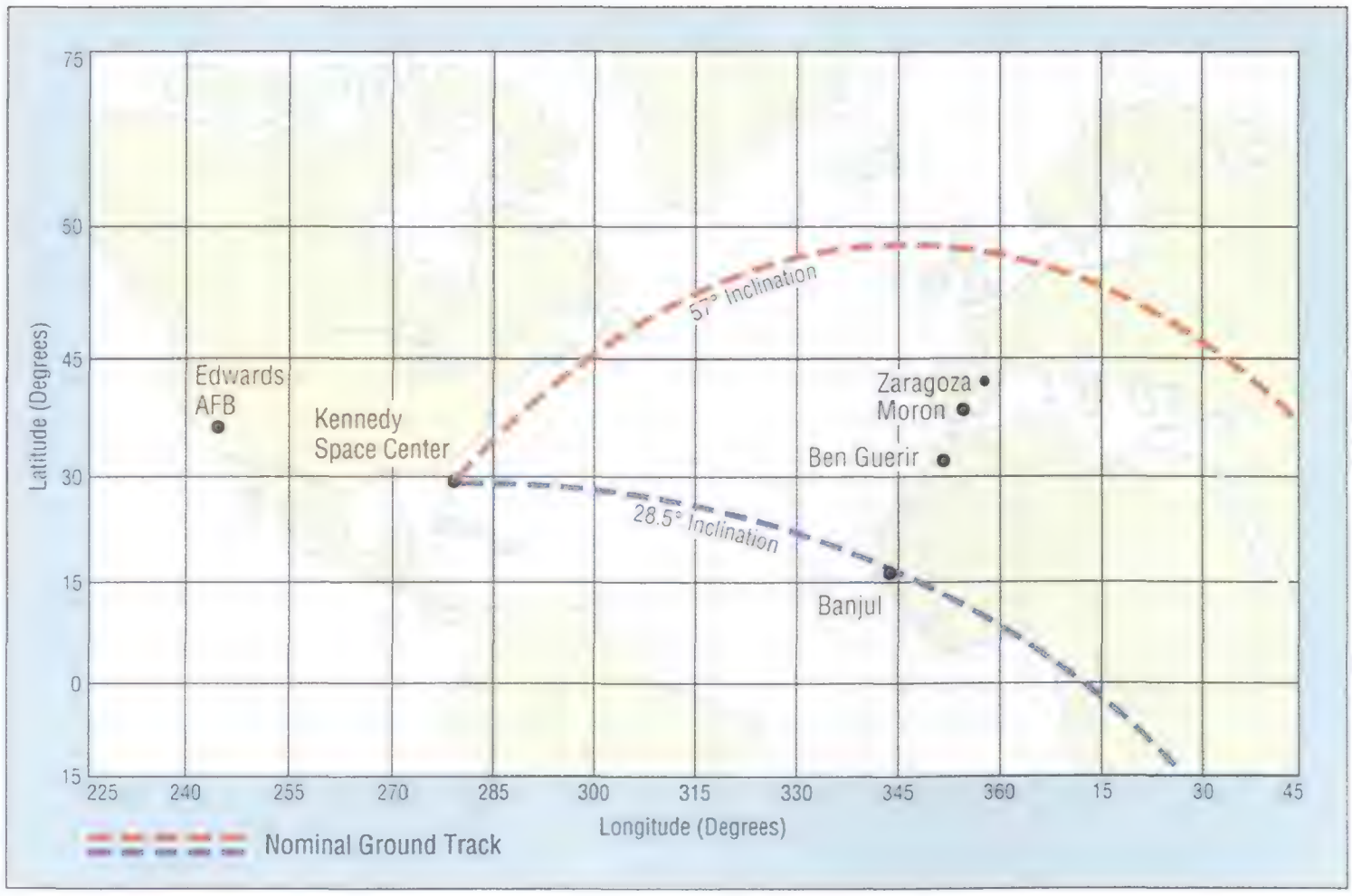
A TAL team arrives in Banjul about a week before a shuttle launch to prepare for the possibility of an emergency landing. Roughly half of the 60 team members are shuttle recovery specialists from two NASA contractors, Lockheed Space Operations and EG&G Florida. The rest are Air Force meteorologists, flight surgeons, and parachute rescue experts. Until recently, trip planners avoided sending women to the two African TAL sites in order to avoid culture clashes in the two Muslim nations.

An astronaut also accompanies each TAL team. David Walker is here to fly a weather reconnaissance airplane prior to the launch of *Atlantis* and flight STS-43 and to be a set of eyes for the astronaut corps. Mission managers want someone on site who has shuttle flying experience and who can judge weather conditions. They also want astronauts to have the opportunity to acquaint themselves with the scrub-palm terrain in case they later become accidental tourists.

The Gambia's subtropical climate makes the TAL team, which is predominantly made up of Floridians, feel right at home. They stay in modern beachfront hotels, which were built to lure European tourists and which contrast starkly with the Third World surroundings. Most of the time, however, TAL team members can be found at the operations building. The brand-new 5,000-square-foot beige metal-sided structure is a marked improvement over previous facilities, which were made out of shipping containers. The 40- by eight-foot boxes had electricity for air conditioning but no windows or plumbing. Although a chemical toilet was available, team members usually preferred to risk wading through cobra-infested weeds clutching a roll of toilet paper.

Astronaut David Walker inspects the Precision Approach Path Indicator—PAPI—lights that are installed to guide a shuttle pilot during landing (above). Walker and Lockheed engineer Jerry Richards also took time to explain the space shuttle to village children.

The NASA compound is located on the grounds of Banjul International Airport, which is 10 miles outside of the capital. Although the runway is long enough to handle jumbo jets, NASA added safety extensions for a shuttle landing. The airport has also been equipped with weather,



NASA chose the Gambia for a transoceanic landing site because it lies on the 28.5-degree ground track used by most shuttle missions. Spacecraft launched at this inclination get an extra boost from Earth's rotation, which allows more payload to be carried.

Curious children from a community near the runway watch Lockheed mechanics Mike Cusmano and Chuck Flory set up strobe lights. Team members returning to the Gambia often bring clothes and toys for these residents of "PAPI village."

communications, and navigation gear to accommodate a shuttle landing.

Should a shuttle ever need to land at Banjul, the crew would lock on to the airport's Tactical Air Navigation system while still 200 miles out and at an altitude of about 360,000 feet above the Atlantic. TACAN would provide the guidance information that enables the orbiter's computers to position the craft for a gliding flight to the runway. The shuttle crew would have little more to do than follow along on their flip charts until about four minutes before landing, when the crew commander would take over manual control of the spacecraft to align the orbiter with the centerline of the runway. A microwave landing system at the airport, which is used in conjunction with TACAN, would provide accurate landing guidance from about 30,000 feet to touchdown.

The TAL team at Banjul would have approximately 30 minutes' notice of a shuttle landing, but it takes almost a week for them to prepare for the possibility. The team must install more than 50 tons of equipment around the runway, including three satellite dishes so that the TAL team can be in real-time contact with both Johnson and Kennedy Space Centers during the shuttle launch. Much of the other equipment consists of a rainbow of lighting, such as the Precision Approach Path Indicator—PAPI—lights, to help the shuttle crew verify outer glide slope. Ball and bar lights help verify inner glide slope, and there are even six flashing strobe lights to help the orbiter crew locate the PAPI lights.

Despite the lengthened runway, the weight of the shuttle's payload and propellants might force the shuttle pilot to stand on the brakes when the shuttle touches down. Since braking alone may not be enough to stop the orbiter before it rolls off the end of the pavement, the TAL team relies on the orbiter arresting system, a 29-foot-high nylon net strung across the runway between stanchions. The net is connected to cylinders in the ground that can absorb the shuttle's energy.

The TAL team works closely with the Gambian officials who run the airport. Some 40 locals assist the team during each launch. The jobs include a weather forecaster, 17 fire

fighters, 20 security guards, and five $2.75-a-day laborers.

On one occasion, more specialized help was needed. Prior to a launch, Greg Meeks, NASA's ground operations manager, was having a problem with some equipment. On a dare, Meeks had a Gambian friend take him to see a medicine man. "He told me we had a devil in the compound, and he wanted 5,000 dalasis [more than $500] to get rid of it," says Meeks. "All of this was going through a translator until I asked him, 'Why so much?' The translator looked at me and said, 'It's a big job.' "

Meeks says he asked the medicine man what he had for about three bucks and got a bottle of rose-scented holy water. Some people on the team claim the medicine man actually came to the compound and performed an exorcism dance. Meeks denies that, but he admits to sprinkling the water on the malfunctioning components "and they all suddenly started working."

Once the site is ready, the TAL team rehearses procedures. The simulations are important for exposing any glitches before an actual emergency. During a recent simulation, the team fell victim to what members refer to as the "Gambian Anomaly," a close relative of Murphy's Law. The mishaps began when a pickup truck fell into a mudhole, causing the technicians to miss their cue to crank up the runway net. A military C-12 twin turboprop was acting as a

During a simulation, a C-12 twin turboprop stands in for the orbiter as Lockheed safety technician Sam Phillips (left) and orbiter technician Jack McAdams rehearse taking air samples. If a shuttle did land here, they would check for leaking toxic fumes.

stand-in for the shuttle; when it finally came to rest on the runway it had rolled too close to two Gambian fire trucks, which had to back up to create the required 1,250-foot safety area at the faux shuttle's tail. Unfortunately, one truck was out of gas. These minor setbacks were all the more embarrassing because the newly appointed U.S. ambassador to the Gambia, Arlene Render, was on board the C-12. Meeks had enticed her to visit NASA's airport compound on her day off with the promise of an airplane ride.

In between work there's little to do in Banjul besides hang out at Bobo's or the Tropic Smile, popular restaurant-bars. EG&G fire chief Buck Tomlinson is partial to Bobo's and has donated enough used paperbacks to the pub to create a library of sorts. Tomlinson knows so many of the locals that each time he returns to Banjul they welcome him home.

Once team members have seen the impoverished conditions in the Gambia, they usually bring boxes of used clothing and toys the next time they come. Many of the items go to children in the "PAPI village," which received its nickname because it's located near the runway lights. When Angie Denny, EG&G's security chief, makes her rounds there she entertains the kids by taking pictures of them with her Polaroid camera.

Even stateside NASA folks have informally

adopted families. Joan Fowler, a data processor at the Kennedy Space Center, organized her fellow EG&G employees to help hotel security guard Kalipha Badjie buy 2,200 cement blocks that he hopes will one day be a dream house for his wife and four children. They currently live in a two-room apartment that lacks electricity and has a puddle of water for a toilet, which is opposite the cooking area.

Gambians such as Badjie, who are aware of their government's role in the Space Age, consider the shuttle a source of pride. Pictures of astronauts and mission insignia decorate market stalls everywhere in Banjul. The locals who observe all the commotion prior to each shuttle launch always want to know when the shuttle will arrive.

So does NASA. It costs the agency $500,000 to set up three sites for each shuttle launch, and beyond a general consensus that the chances of an overseas landing are remote, nobody is willing to venture odds on whether a site will ever be used. "Nothing would make us any happier than to never have to use a TAL site," says David Walker, "but my personal guess is we'll probably use one in the next 15 or 20 years. Then all four of them will have paid for themselves many times over by saving a $2.2 billion orbiter and [its] crew."

Playing the role of Maytag repairmen—always on call but never called on—can be frustrating. "Nobody wants it to land here, but I get a little let down when we do all this work and then pack it up and go home," laments Greg Meeks, who has made 12 trips to the Gambia in three years. "Sometimes we pull off a miracle to get everything working and everybody in place," he says.

"If it does come in here," Appolloni says, "first, we're gonna be here a while. Second, it's going to be—"

"A madhouse," Meeks chimes in.

Finding a place to park the shuttle would be one problem. Another would be finding accommodations for the 500 people who would suddenly converge on the airport, including both a rapid-response team and a mishap investigation team. NASA estimates it would take perhaps as many as 77 trips in C-5 and C-141 cargo planes to bring workers, equipment, and supplies to the Gambia.

It would take at least two months to get the shuttle back to the United States. A barge would have to deliver two cranes, one capable of lifting 800 tons and the other 250 tons, to hoist the orbiter onto its 747 ferry jet. NASA estimates that if everything went according to plan, the orbiter would be on the ground in Banjul for 52 days, and the entire operation would take 64 days.

"We certainly hope if it happens, it happens in the summertime, because if the hotels are full, we're gonna build a tent city out here," Meeks tells the ambassador during her visit to the NASA compound.

If the orbiter should ever land in the Gambia, the time of year won't affect the reception the spacecraft will receive from the local population. By now the country has developed a fascination with the shuttle that is sure to result in a multitude of curiosity seekers. As the ambassador herself predicts, "Half of the Gambia will be here and all of Senegal."

The space shuttle has become a cultural presence in the Gambia, appearing in a mural (above) and in the work of wood carver Aramata Jallow from Banjulundin village (opposite).

The Passing of a Pioneer

William Gregory
former editor,
Aviation Week and Space Technology

Pan Am's fate can't be blamed solely on deregulation.

I know that times change and a reputation won't convert into hard currency, but I can't watch an airline disappear without feeling a pang. And sadly, they are inexorably fading away: Braniff, Western, National, and Eastern are gone, while TWA, Continental, and Northwest are teetering. Saddest of all is the recent loss of Pan American World Airways, a name that was once synonymous with pioneering—the establishment of new routes and the development of new airplanes.

Deregulation, so unforgiving of error, probably deserves some of the blame for the demise of many airlines. Even the misfortune of having a regulation-era route structure in a hub-and-spoke world can mean the end in today's world. Still, Pan Am's fate can't be blamed solely on deregulation; the airline had started to dig its own grave a long time ago.

When it was founded in the 1920s, few would have predicted Pan Am's eventual global reach. On the Latin American routes that Pan Am plied when it was just getting started, competition meant putting sand in a rival airplane's fuel tank. Pan Am did have a flair for staking out its place in history and capturing the public imagination. When I was a boy, I admired Captain Ed Musick more than Dizzy Dean or Lou Gehrig. Musick was the clear-eyed, jut-jawed captain who flew the well-publicized China Clipper that opened Pan American's Pacific service. It was no coincidence that the Clippers were named after the fast ships that had propelled the U.S. merchant marine into the big leagues.

Unlike other pioneering U.S. airlines, Pan American had been designed to fill the role of flag carrier for the United States. Juan Trippe, Pan Am's founder, never really got the formal cooperation of the U.S. government in pursuing that end, yet he made his airline an instrument of national policy in the fashion of British Overseas Airways, Air France, KLM, and Lufthansa. These dominant international carriers functioned as an arm of diplomatic and trade policy, devising routes and schedules as much to further national interest as to meet commercial needs.

Even though most of those airlines were state-owned, they still wanted to operate profitably. So they set fares through an international trade association—a cartel, said critics—that Pan Am came to dominate. Tariffs were high enough to produce profits from prestige routes that lacked passenger traffic. And airlines would use revenue from their fat routes to subsidize the lean.

True to that grand tradition, Pan American operated two round-the-world trips—one eastbound, one westbound—more for prestige than for profit. It hung on to a money-losing route to Moscow because the government had assigned it to Pan Am, and whatever it took, Pan Am would fly it. In its best flag carrier mode, Pan Am once operated one flight to Latin America through Houston in the morning and a return trip late at night. Each flight required its own two ground crew shifts to handle the incidental stop it made in Texas.

Like its domestic counterparts, Pan American matured at a time when regulated fares were high enough to allow increases in labor costs to be passed along to the consumer. Most airlines accepted union demands rather than face a strike, and the results were inevitable: high wages and burdensome seniority rules. Pan Am further inflated its payrolls by insisting on hiring its own ground crew wherever it flew—originally a sound idea but outmoded in modern times—rather than contracting the service out to a competent local airline at far less expense.

Above all, Pan Am was the offspring of Juan Trippe, its Yale-educated, Wall Street-trained financier-founder. His airline set the mode that others would follow. It helped design airplanes for its own needs, such as the Sikorsky and Boeing flying boats of the 1920s and 1930s. Trippe was a driving force behind the first-generation Boeing 707 and the Douglas DC-8 as well. He ordered 20 707s and 25 DC-8s, nice round numbers that

Pan Am was once a giant among airlines, but its glorious past became the cause of its demise.

would get the assembly lines rolling. The airlines had little experience with jets, and Trippe didn't know which would succeed. So he put his chips on both.

Times changed, but Trippe did not. He continued to run the airline virtually singlehanded. At one point he got into a row with Donald Douglas' son, Donald Jr., over the DC-8. Never afterward would he let a Douglas salesman into his headquarters, though the time was coming when Pan Am might well have used the three-engine, long-range DC-10. Eventually, Pan Am would need concessions from manufacturers more than the manufacturers needed orders from Pan Am.

The Boeing 747 provided a watershed of sorts. In the classic Juan Trippe pattern, Pan Am helped size and design the airplane, then kicked off the program with another nice, round order for 25 to get the manufacturer committed. But the 747 was a quantum leap for any airline, even Trippe's. Its price and operating costs mandated passenger loads and routes matched to its size. Instead of carefully analyzing the new airplane's demands and the number he needed to buy, Trippe tried to operate on intuition. He ordered eight more 747s instead of waiting for the inevitable improved versions, and when airline traffic abruptly decreased in the early 1970s, Pan Am's operations people ended up spending years trying to figure out how to schedule them.

Other airlines began shifting to formal, analytical fleet, route, and profit planning systems, but Pan Am's planning went on almost entirely in Trippe's head. The virtues that had enabled Trippe to build Pan Am had become vices. When he retired in 1968, his plans and strategy, flaws and all, went with him. Instead of inheriting a formal corporate strategy to build on, Trippe's successors were left to wing it.

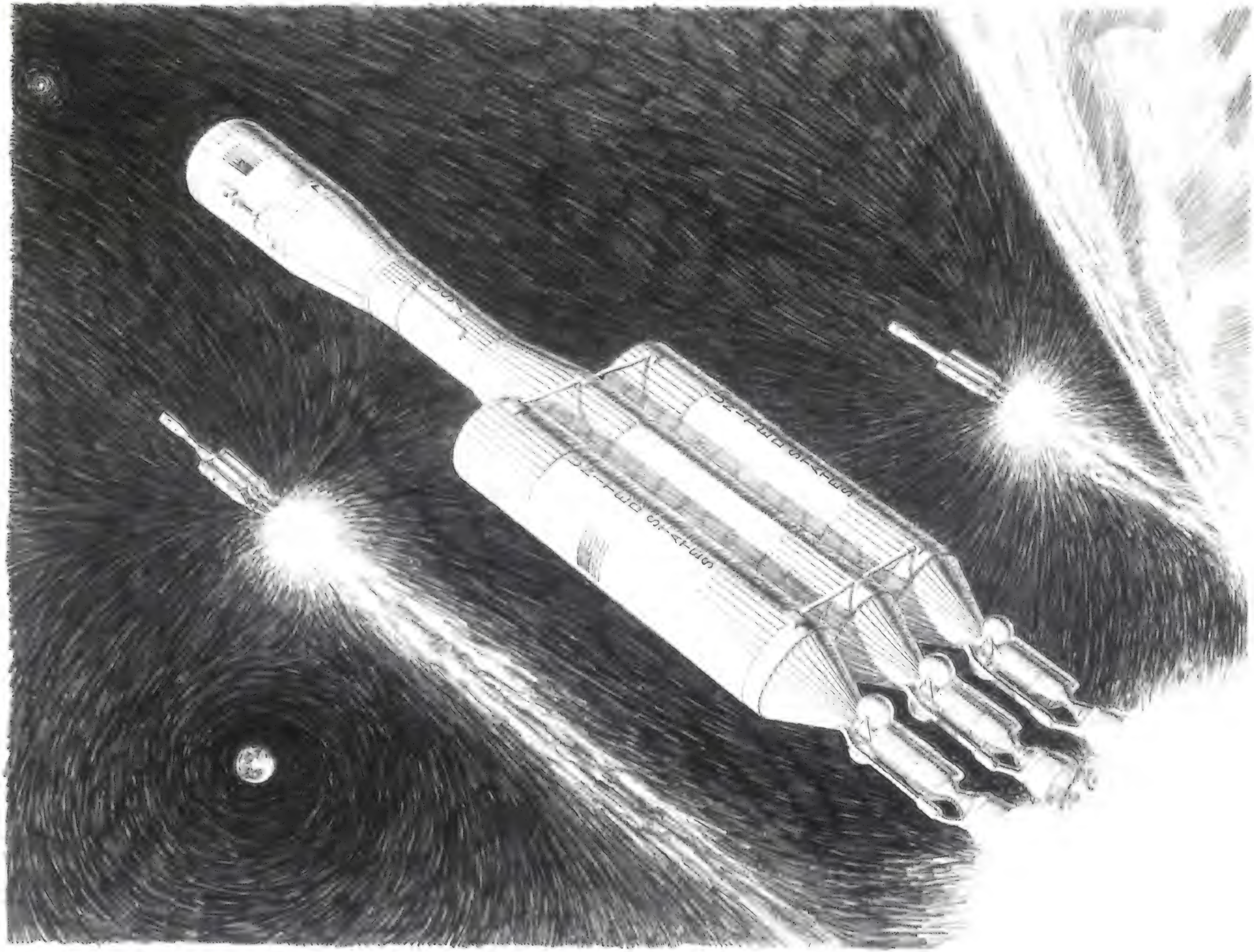
As the airline bled money in the 1970s, standards began to slip. I recall flying on one of Pan Am's older 747s from Tokyo to New York. Soon after the trip I ran into John Borger, the airline's chief engineer, who asked me how the 747 had looked. I told him the unvarnished truth: the airplane looked grungy. The carpets had shrunk, exposing the underfloor; one reading light kept flickering off and on; the lavatories were dirty; the seat fabrics were worn; the cabin side panels needed washing or painting.

Borger shook his head sadly. Those airplanes needed more than the minimum FAA-mandated engine and airframe maintenance—they needed housecleaning and redecorating. But by that time the airline was on the downside of the financial curve and lacked the resources to refurbish its airplanes, let alone buy new ones.

Pan Am's dream of becoming a flag carrier finally died in the economic revolution of deregulation. The airline tried to become a hustling commercial operator; in order to gain a domestic route system to feed passengers into its pricier long-haul international flights, Pan American bought National Airlines. Though the merger is considered Pan Am's grossest mistake, Pan Am did need a domestic feed and the concept was sound—the disaster was in the execution. The two airlines were never properly integrated, neither in terms of pilot seniority lists nor in the effort to combine National's short-haul routes and aging 727 fleet with Pan Am's global routes and aging long-haul 747s. Two weak companies became one weak company.

Pan Am tried everything: low fares, schedule shuffling, emphasizing one market segment or another. But the downward spiral wound tighter and tighter. To finance day-to-day operations, Pan Am began to sell off its assets, first its real estate, then the Pacific routes it had pioneered. In the end, Pan Am was back where it had been at the start: it was left with only the Latin American routes that had proved Juan Trippe's contention that his flying boats could operate with reasonable safety and more or less on time. And even those routes were riddled with deficits. Pan Am's time had passed, and with its passing a chapter of aviation history comes to a close.

When Juan Trippe retired, his plans and strategy went with him.



by Gregg Herken

Illustrations by Carter Emmart

Has the chemical rocket gone about as far as it can go?

THE NUCLEAR OPTION

When he announced the Space Exploration Initiative in July 1989, President Bush may have started NASA down a rough road. The finale of Bush's plan is a manned trip to Mars—a journey that more and more space experts agree will require a nuclear rocket. The Synthesis Group, a panel convened by the White House to recommend the best ways to achieve Bush's space goals, handed down that opinion last May. Using a word that the president is known to admire, the group concluded that the "only prudent propulsion system for Mars transit is the nuclear thermal rocket."

Chances are that when average Americans hear the word "nuclear," the next word to come to their minds is not "prudent." They would more likely flash on images of mushroom clouds or power plant accidents. Yet despite this image problem, three federal agencies are reviving some 1950s ideas for using nuclear fission in a rocket engine.

The paradox of the Synthesis Group's recommendation is that in the incomparably dangerous business of space exploration, nuclear propulsion is a safety measure for the astronauts. "When we set the criteria for the mission, crew safety was number one," explains physicist Richard Burick, a member of the Synthesis Group and current coordinator for new space programs at the Los Alamos National Laboratory in New Mexico. "We had to come up with something that would reduce trip time. You don't need to be a genius to come up with the idea that you need a high-performance engine."

Even the most efficient chemical rocket would take up to 500 days to reach Mars and return. During that time, the ship's crew would be subject to micrometeoroids, solar flares, cosmic rays, the bone decalcification and muscle atrophy that accompany long stays in microgravity, and—not least of all hazards—each other's company. A nuclear rocket could cut that travel time almost in half.

The appeal of using atomic energy for rocket propulsion has always been a matter of numbers. A rocket engine's efficiency is measured by the pounds of thrust it can achieve from the pounds of propellant it burns over a certain period of time. The product of this formula—the engine's "specific impulse"—is expressed in seconds. The higher its specific impulse, the greater the engine's efficiency. Today, advanced chemical rockets like the shuttle's main engine have a specific impulse of about 450 seconds. By comparison, a nuclear rocket engine tested in 1969 at a Los Alamos facility had a specific impulse of 845 seconds. Seconds of specific impulse translate into days—or months—of travel time in space.

Once in deep space, a nuclear reactor may be a technologically prudent system. But here on Earth, nuclear anything is a political hazard. The outcry that greeted last April's news of a top-secret Department of Defense program shows how difficult it may be to sell the public on nuclear propulsion. Newspaper accounts described the project, code-named "Timberwind," as a nuclear rocket that would be launched directly from Earth or started in suborbit as a kind of "superbooster" to put heavy military payloads in space quickly. Steven Aftergood, a senior research analyst at the Federation of American Scientists who exposed the Timberwind story, speculates that the rocket might also be intended for use as an anti-ballistic missile or anti-satellite weapon.

The Pentagon's Strategic Defense Initiative Office, Timberwind's sponsor, "has displayed remarkable contempt for the safety issues," says Aftergood. According to briefing papers for the project, the SDIO proposes flight testing the rocket off Antarctica in order to minimize exposure to its radioactive exhaust and to lessen the probability that the rocket's reactor would land on a populated area. Even so, the planners admit that there is a finite possibility—4 in 10,000, they calculate—that a wayward nuclear rocket would hit New Zealand.

"What appalls me about the DOD nuclear propulsion program is that there's no opportunity to oppose or criticize it," says Aftergood. "Maybe it's safe, maybe it's not." He claims that so far taxpayers have spent $185 million on a classified program that they cannot debate.

The unclassified, debatable variety will cost them about $12 million this year. NASA has budgeted $7 million for research on nuclear rockets, and the Department of Energy is spending about $5 million on various studies. Both efforts are resurrecting ideas from an earlier age of atomic power.

Even before there was an atomic bomb, there was the idea for a nuclear-powered rocket, but it was not until after the bomb that the atom's potential use in space exploration was also taken seriously. The overnight realization of the amount of energy available to propel mankind to the stars "made everybody's skin tingle a little," says Raemer Schreiber, a physicist who retired from the Los Alamos laboratory in 1974.

Schreiber, who worked on both atomic bombs and atomic rockets, managed

Many of today's designs for nuclear propulsion systems stem from ideas developed in the late 1950s. NERVA (Nuclear Engine for Rocket Vehicle Application), which was conceived more than 30 years ago for a Mars spacecraft, has inspired the current work on solid-core nuclear thermal reactors being conducted at NASA's Lewis Research Center.

Additional research and material for this article was provided by Linda Shiner.

the only nuclear rocket program to reach the stage of full-scale tests. He was one of almost a hundred members of the lab's secret "rocket society," formed to investigate the feasibility of nuclear-propelled ballistic missiles to rain bombs upon the enemy. Once chemically powered ICBMs like Atlas proved their worthiness for that purpose, the society shifted its attention to atom-powered rockets for exploring the cosmos. For Schreiber and his colleagues, many of whom were daily engaged in the design of nuclear weapons, the society's new focus was a welcome diversion. "To be frank, things were getting a little dull in the weapons business," he says.

Schreiber's program was a proof-of-concept study code-named Rover. Begun under the Eisenhower administration, Rover and a companion program, NERVA (Nuclear Engine for Rocket Vehicle Application), cost $1.4 billion—the equivalent of more than $10 billion today. They were canceled in 1972, victims of shrinking NASA budgets and declining public interest in space following Apollo.

"Rover starved to death," Schreiber recalls today with some bitterness. But before it did, Schreiber's team successfully built and static-tested nuclear thermal rockets in the Nevada desert.

Nuclear thermal rockets, NASA's current choice for Mars transit, produce thrust by vaporizing and ejecting a propellant, just as chemical rockets do. But in a chemical rocket the propellant releases energy through combustion; in the nuclear rocket it is vaporized by the heat produced from the controlled fission of uranium 235.

The factor limiting the performance of nuclear rockets is the heat tolerance of the engine's structure. The highest operating temperature Rover could sustain was about 4,775 degrees Fahrenheit. Later advances in high-temperature materials have contributed to the plans to revive Rover's technology. The aim of the Synthesis Group is a nuclear rocket engine able to operate at 6,065 degrees Fahrenheit, producing a specific impulse of 925 seconds.

By fashioning the reactor core out of special ceramics and cladding it with heat-resistant material like industrial diamond, operating temperatures of 8,540 degrees Fahrenheit or more may be possible. A nuclear rocket powered by a gas core reactor—in which the materials problem is sidestepped by making the heart of the engine itself a plasma, or high-temperature gas—could theoretically travel to Mars and back in just three months.

The advent of new high-temperature materials has in turn made it possible to envision new types of nuclear reactors, variations that might give nuclear thermal rockets twice the power at half the weight of those a generation ago. The engines of Rover/NERVA relied upon a conventional nuclear reactor, in which slugs of uranium in long metal rods are suspended in a graphite lattice. Future nuclear rockets may derive their power from so-called particle bed reactors, in which tiny pellets of carbon-clad uranium fuel are embedded in porous graphite or ceramic blocks. Because more surface area is exposed by the pellets than the rods, particle bed reactors are smaller and more efficient than conventional reactors, and thus require less shielding.

The matter of shielding, of course, points to the single glaring defect shared by all nuclear rockets. The engine itself is made radioactive by firing the rocket. And radioactive fission products, like the deadly strontium 90 and iodine 131, can escape in the exhaust.

Advocates of nuclear propulsion plan to get around this hazard by lofting the reactor "cold"—with a chemical booster—and starting the nuclear upper stage in space. Once the nuclear rocket has done its job, the radioactive core would be sent into a higher orbit or shot directly into the sun.

Unlike the military's Timberwind, civilian nuclear rockets are intended only for operation in space, far away from Earth. That way the radioactive exhaust wouldn't contaminate the atmosphere. Richard Burick believes the rockets would add only a negligible amount of radioactivity to that in space already. "Outer space is a logical test bed to build the technology and show you can handle it," Burick says.

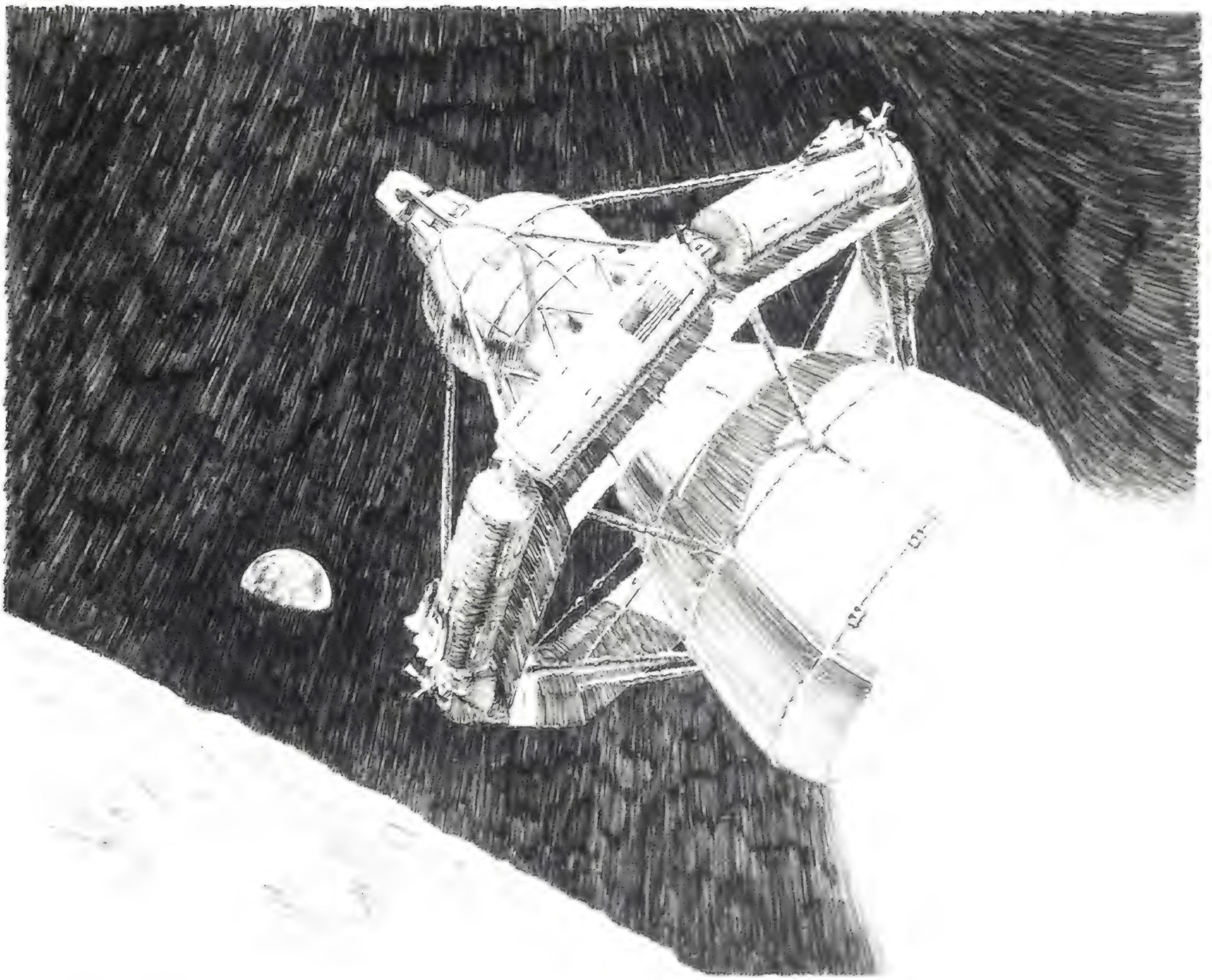
Nonetheless, NASA and DOE are proceeding warily. Some of the research now under way at the Lewis Research Center in Ohio is aimed at finding ways to minimize the radioactivity of the rock-

Overachiever

Every kid who has put a firecracker under a tin can understands the principle of using high explosives to loft an object into space. What was novel to scientists at Los Alamos was the idea of using an atomic bomb as the propellant. That strategy was the serendipitous result of an experiment that had gone somewhat awry.

Project Thunderwell was the inspiration of astrophysicist Bob Brownlee, who in the summer of 1957 was faced with the problem of containing underground a nuclear explosion, expected to be equivalent to a few hundred tons of dynamite. Brownlee put the bomb at the bottom of a 500-foot vertical tunnel in the Nevada desert, sealing the opening with a four-inch-thick steel plate weighing several hundred pounds. He knew the lid would be blown off; he didn't know exactly how fast. High-speed cameras caught the giant manhole cover as it began its unscheduled flight into history. Based upon his calculations and the evidence from the cameras, Brownlee estimated that the steel plate was traveling at a velocity six times that needed to escape Earth's gravity when it soared into the flawless blue Nevada sky. "We never found it. It was gone," Brownlee says, a touch of awe in his voice almost 35 years later.

The following October the Soviet Union launched Sputnik, billed as the first man-made object in Earth orbit. Brownlee has never publicly challenged the Soviets' claim. But he has his doubts.



Like NERVA, Helios dates back to the '50s. Physicist Pete Mohr of the Lawrence Livermore Laboratory in California designed a mammoth craft to be propelled through space by successive explosions of atom bombs inside its gigantic engine.

et's exhaust. And one member of the Synthesis Group cautioned NASA by remarking that it would certainly be a shame, after spending thirty years and $40 billion trying to get to Mars, to reach the moment when the rocket is on the launch pad only to be stopped by a lawsuit. He was no doubt thinking of the suit the Christic Institute brought against NASA in 1989 to block the launch of the Galileo space probe, now bound for Jupiter, and of the subsequent protests against the Ulysses solar probe. Galileo and Ulysses are powered by radioisotope thermoelectric generators (RTGs). An RTG produces electricity by converting heat from the radioactive decay of plutonium 238. The electricity is used to power the craft's instruments, not to propel it through space.

The major concern of the Christic Institute and other groups who protested the Galileo launch was that if the shuttle failed catastrophically, it would spew plutonium all over south Florida. Steven Aftergood and members of the Federation of American Scientists and the Committee of Soviet Scientists for Global Security last year called for an international ban on RTGs for any craft other than deep-space probes, mainly because of the danger of collisions with debris in low Earth orbit. But Aftergood himself points out that "RTGs are radioactively hot at launch. Reactors for propulsion are not initially radioactive. They only become radioactive as a by-product of operation. We are open to the commencement of reactor operation within Earth orbit. But we'd want to know things like: How much do you gain? What would be the increase in safety margin for the astronauts [to offset the risk]?"

Other critics of RTGs aren't as quick to make the distinction. Bruce Gagnon, the state coordinator of the Florida Coalition, admits that he hasn't read much about NASA's plans for nuclear propulsion. "But I have a visceral reaction," he says, "and one based on experience. [Nuclear power for space] is just another case of the nuclear industry trying to develop a market. This confirms everything we've said all along. We said Galileo and Ulysses were icebreakers. Once they used nuclear power, people would get accustomed to these uses and it can be used for more things. If you put a frog in boiling water, it jumps

VISTA (Vehicle for Interplanetary Space Transportation Applications) is being developed by Pete Mohr's younger colleagues, Rod Hyde and David Morgan. Their concept replaces Mohr's atom bombs with tiny pellets of thermonuclear fuel ignited by lasers.

out. But if you start it out in cold water and gradually increase the heat, it stays in long enough for you to kill it.

"We take a broader view. We're worried about the production and mining and manufacturing. And we'll do everything in our power to stop it. We want to shut this entire nuclear wizardry down. We just can't allow this industry to develop this new market."

These are the kind of sentiments that worry Joel Sercel, a scientist working on nuclear electric propulsion at the Jet Propulsion Laboratory in California. Because of the public perception of nuclear power, Sercel thinks "all different advanced propulsion options have to be considered with meaningful research. Besides nuclear, there's high-performance chemical with aerobraking, solar electric, and solar thermal. It's too early to down-select now."

Sercel believes that the dangers in nuclear propulsion are mainly those of public perception. "There is some risk," he says. "You can do anything stupidly. But it can probably be done intelligently." Says another source familiar with NASA's nuclear efforts, "We know we have to do this right."

"The open program has demonstrated an admirable awareness of the safety problems involved," Steven Aftergood says, "primarily through the work of the Nuclear Safety Policy Working Group."

Headed by Albert C. Marshall, an independent nuclear safety advisor for reactor systems at Sandia National Laboratories in New Mexico, the 12-member panel was one of six groups formed from workshops in the summer of 1990. The NASA-sponsored workshops provided the first opportunity for the nuclear community as a whole to look into nuclear propulsion for space travel. "Anybody who works in nuclear is always involved to some degree in safety," says Marshall. "Our job was to identify what the risks are and to recommend nuclear safety policy requirements and guidelines." After a year of work, Marshall's group submitted its report to a NASA/DOE/Air Force steering committee last September. "The way to do this properly is a systematic approach," Marshall says. "In each phase, look at every possible problem, even those things that seem absurd. The lists get very long. It's tedious. It's gotta be done." The working group looked at every aspect of nuclear propulsion, from manufacturing and ground tests to ground transportation of the system, pre-launch, launch, operations, and disposal.

Obviously, sensitivity to nuclear haz-

ards has increased since 1969, when NERVA engines were tested at the Los Alamos facility in Jackass Flats, Nevada. The engines were attached to the test stand nozzle-up, their radioactive exhaust shooting straight up into the atmosphere. One experiment, the Total Nuclear Test (TNT), deliberately exploded a rocket to see how bad the contamination would be. Workers at the test site donned protective clothing and picked up the pieces of the exploded reactor. "That was not a good thing to be doing," says Marshall. "That was a different time in our understanding."

"I think there is an awareness within the programs that what they could get away with in the 1960s they couldn't get away with now," says Aftergood. Nonetheless, he points out, the Department of Energy test facilities are not legally bound by Nuclear Regulatory Commission standards. "In the past we have argued that one way to assure the safety of facilities and to enhance pubic confidence is to establish licensing procedures," he says. "At the moment, DOE facilities are not licensed and the rules are modified to fit the programs rather than the other way around."

"The Interagency Nuclear Safety Review Panel has established elaborate procedures to ensure safety," says Marshall. "Each project must produce a preliminary and updated safety analysis."

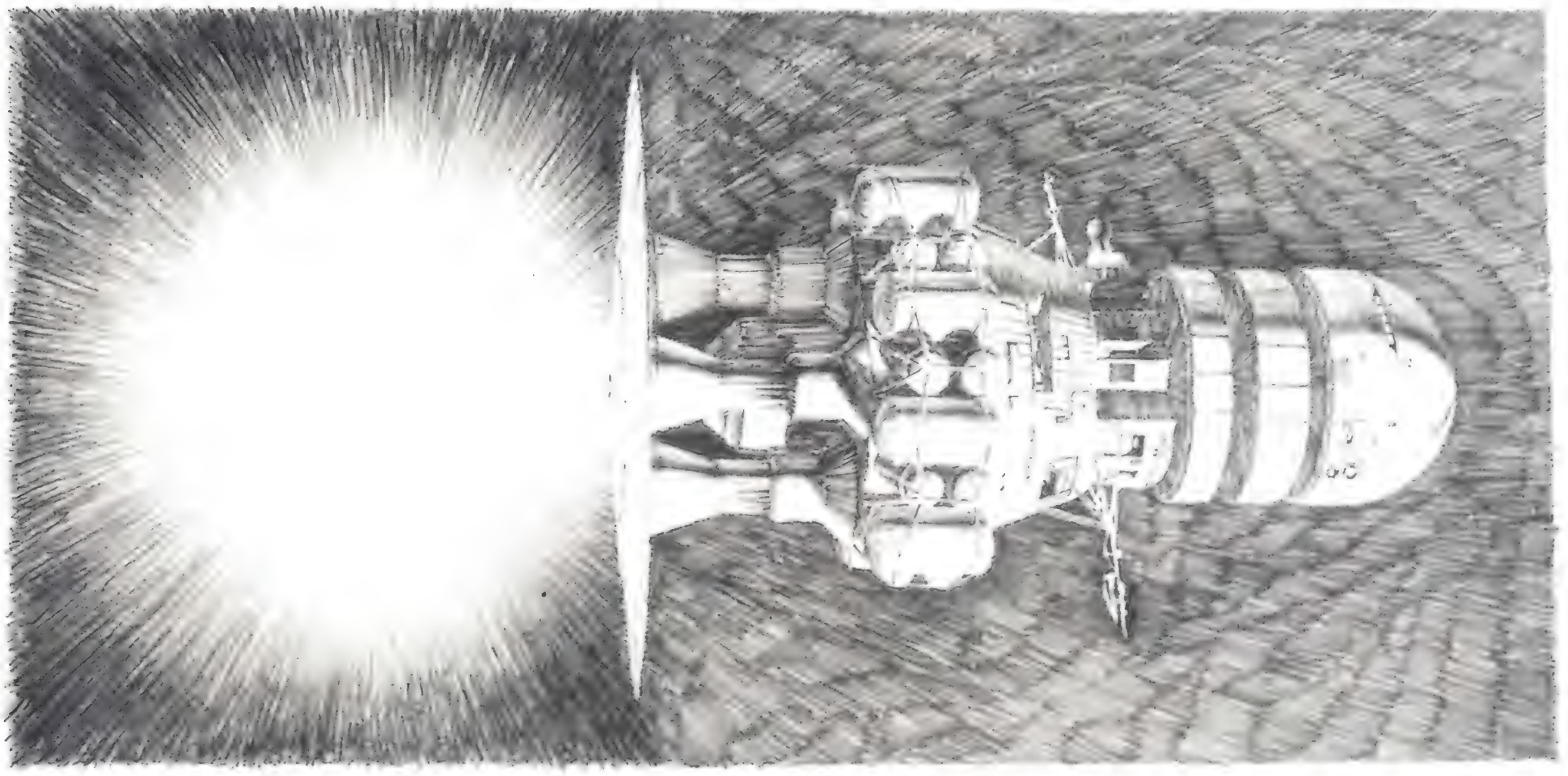
"We have no intention of not scrubbing the exhaust," says Richard Burick. Minimizing the danger of contamination, he calls nuclear ground testing "an engineering problem, not a physics problem."

Even if the public can be sold on nuclear rockets, their return is still far from assured. Ironically, advances in another technology—microelectronics—have undermined one of the earliest justifications for nuclear propulsion: if radiation-hardened robots and computer chips can replace vulnerable astronauts in exploring space, travel time to the planets becomes less important. "You no longer have to have somebody around to change the vacuum tubes," quips Rover veteran Schreiber.

Several advocates of nuclear propulsion see the Space Exploration Initiative as an opportunity to improve the image of nuclear power. "There is an emotional side to this thing," says Richard Burick. "Nuclear's a dirty word. The biggest thing to come out of SEI may be to show Mr. John Q. Six-Pack that we can do this in an environmentally responsible way."

Perhaps the image of nuclear propulsion is worse than the reality. "Space nuclear power is a relatively obscure field that will suffer from the execrable record of terrestrial nuclear power," says Steven Aftergood. "I don't think it's hysterical to view nuclear power cautiously when virtually every government facility is contaminated."

For now, NASA is keeping its work on nuclear propulsion low-key. Once again, it seems likely that politics and popular opinion, rather than technology, will decide whether the nuclear rocket ultimately gets off the ground.



Perhaps the most famous of the early atomic-powered spacecraft, Orion was the work of physicists Freeman Dyson and Theodore Taylor. A series of nuclear explosions behind a "pusher plate" would provide a bumpy ride through space. A reincarnation now being investigated at the Los Alamos National Laboratory replaces the pusher plate with a parachute-like shroud connected to the spacecraft by a long elastic tether. In this configuration, the spacecraft would be pulled, rather than pushed, in a rhythmic jellyfish-like motion—hence the spacecraft's name: Medusa.

Come to Aruba When the Barium Blooms

An informal gathering in the Caribbean attended by a dozen scientists, two KC-135s, and a satellite.

by Linda Shiner

Photographs by David Nance

Master technician Tom Hunwardsen lay on his back on a scaffold and aimed a flashlight at an opening in the wing of a KC-135. "Can you get it?" Hunwardsen asked his buddy, Tom Harrison, a communications and navigation systems technician working armpit-deep in the wing. Harrison just grunted. A lot was riding on the outcome: tonight Air Force tanker 553127—just 127 for short—was scheduled to fly a dress rehearsal. At stake was the success of a key step in one of the most elaborate series of experiments ever devised to study Earth's ionosphere and magnetosphere.

With the exception of another KC-135 parked next to 127, the Queen Beatrix International Airport on the island of Aruba was deserted, the last arriving planeload of tourists having scattered to seaside resorts and casinos. The two modified tankers, vaguely threatening with their gray paint and military insignia, looked a little out of place in this Caribbean setting.

Around number 127, which had its lights on and a side hatch open, about a dozen members of the 4950th Test Wing and a group of scientists were talking. They had arrived the day before from Wright-Patterson Air Force Base in Ohio, and tonight the crew would fly a short distance into Venezuela, 18 miles to the south. Once aloft, the scientists could calibrate their instruments and locate the starfields where they would aim their cameras. But 127's right outboard spoiler had stuck in the up position, and nobody would be doing any calibrating until it was fixed. While the team waited, the satellite they had come to meet was circling Earth as relentlessly as a hand sweeping the face of a clock.

The Combined Release and Radiation Effects Satellite had been launched on July 25, 1990, by NASA and the Air Force. Almost exactly 849 orbits later, it would be in position to create a spectacular light show over the Caribbean at 4:30 a.m. At its launch, CRRES carried 24 canisters to be ejected into space by springs. Most contained barium but

It's show time aboard the Thunder Chicken *as John Wolcott, Tim Heywood, and Gene Wescott (front to rear) observe the results as barium atoms are released from the Combined Release and Radiation Effects Satellite. Sensors aboard the aircraft enable the scientists to count barium ions that migrate along Earth's magnetic field.*

some held strontium or lithium. When an ejected canister was about two miles from CRRES, its contents were heated to thousands of degrees to form a vapor. Atoms of the vaporized alkaline metals glow in the sunlight and form a bright cloud that's visible to an observer watching from the night side of Earth. Presto! Instant aurora. In space, neutral barium atoms glow green, but the sun's ultraviolet radiation quickly knocks away the negatively charged electrons from some of the barium atoms, creating positively charged ions, which glow blue-violet. Physicists monitoring the experiment could see what happens when a cloud of charged particles explodes in the ionosphere, the outermost layer of Earth's atmosphere.

CRRES had already popped 17 canisters—13 over Canada in January and February 1991 and four over the South Pacific the previous fall. That left seven for Aruba. But the satellite was in an eccentric orbit, with its apogee 22,187 miles high and its perigee, where the canisters were released, at just 217 miles. And the relative positions of Earth and the satellite were gradually changing. By July the spacecraft's perigee

Before takeoff the ground crew removes a protective coating applied to the observation windows after each flight.

was just to the west of Antigua and slowly drifting south. The positions of the sun and moon also came into play: the releases had to be made in sunlight but observed in moon-free darkness. It all boiled down to nine chances to do seven experiments, and tomorrow night would be the first chance.

Jim Harrison, the maintenance crew chief on number 127, pointed to the man with his arms deep inside its wing. "That's my son over there," he said. "He's a com-nav man. But he pitches in on any job. They all do. They're a real good bunch." According to Air Force tradition, crew chiefs name their airplanes. Harrison had named 127 the *Thunder Chicken* because, he said, "She sounds like thunder and flies like a chicken."

Once a faulty connector had been detected the pressure on Harrison had eased, but he was acutely aware that he still had to get the airplane flyable. At every stage of the program so far this old tanker had exasperated its crew and alarmed the scientists. The *Thunder Chicken* joined the Strategic Air Command in 1957 and had the distinction of being the very first KC-135 delivered. But the airplane had earned its current reputation when it blew an engine over the Pacific on the way to Samoa last fall and arrived a day late for its first CRRES flight. "Yeah, she'll scare ya and she'll aggravate the hell out of ya, but she won't hurt ya," Harrison said. The crew chief may beef about the airplane, but it's clear he wouldn't take kindly to the same talk coming from anyone else.

Finally the spoiler was fixed and technicians and flight crew clambered up the boarding ladder. The maintenance crew gathered on the runway's edge to watch the takeoff. Hunwardsen inserted earplugs as the airplane taxied to the far end of the runway, and the two Harrisons laughed as they recalled the farewell they had given Wright-Patterson the day before. Unlike most tankers, which had been outfitted with quieter, more powerful turbofans starting in 1982, the *Thunder Chicken* still had its original J-57 turbojets. When it took off from Wright-Patterson carrying a heavy load, Jim Harrison had found it necessary to order water injection, which boosts the thrust from each engine by 1,800 pounds. It also adds noise. "We went tearin' outta there, those engines crackin' and poppin'," he said. "It was two in the morning. I bet the switch-

The Barium Bomb

Vaporizing alkaline metals is tricky, as scientists who had worked at the Max Planck Institute's Gärching Laboratory in Germany in the early 1960s will tell you. Chemist Herman Föppl worked in a small outbuilding with a roof designed to be blown away in an explosion so it wouldn't crash down on him. While Föppl experimented, calling out each step so no mistake would ever be repeated, a single observer watched and recorded the proceedings from behind a thick window. One serious accident hospitalized Föppl for several months with severe burns, but finally he and physicist Friethelm Melzner developed a technique to liberate barium atoms.

Such risky work was undertaken to provide Ludwig Biermann with a man-made comet. Biermann knew that a comet's tail always points away from the sun, and in 1951 he hypothesized that the tail was being pushed by streams of solar particles. These particles have since been confirmed and are known as the solar wind.

Biermann's plan to create an artificial comet drove the group at the Gärching Laboratory for decades. "It was a very exciting time," says Gerhard Haerendel, a theoretical physicist who studied under Biermann and later served as a principal investigator in the CRRES program. "I like to say we were completely innocent. We had no idea what we could and couldn't do. We just tried."

Erich Reiger, another physicist, remembers one try that gave them all a good scare. The scientists placed one of Föppl's barium canisters in a field where they conducted experiments, stood off about a hundred yards, and ignited it. A piece of the canister shot across the field to a construction site 300 yards away, narrowly missing the cab of a crane. The crane operator climbed down and stormed across the field. "We had to buy him a lot of beers to calm him down and keep him from complaining about us," Reiger says.

By 1964, when the institute produced the first barium cloud in space, the existence of the solar wind was common knowledge. Twenty years later, during the Active Magnetospheric Particle Tracer Explorers mission, a German satellite released barium and lithium into the solar wind and the magnetotail, the area of the magnetosphere on the "lee side" of Earth, while British and U.S. satellites traced the movement of the resulting ions. The artificial comet had finally been born.

board at the base lit up like a Christmas tree."

As the *Chicken* rumbled down the runway and took off for Venezuela, Jim Harrison pumped his fist to the sky. Even without water injection, the airplane was astonishingly loud.

CRRES was born at Huntsville, Alabama's Marshall Space Flight Center in 1974 as part of an effort to understand the sun's influence on Earth and part of Marshall's effort to stay alive in the post-Apollo period. Anticipating the space shuttle's predominance in the civilian space program, the center met with scientists to plan how to use the shuttle as an orbital laboratory. One group focused on AMPS—experiments in Atmosphere, Magnetosphere, and Plasmas in Space, continuing the investigation of near space that the first U.S. satellite had begun. Launched in 1958 on a Jupiter C that Wernher von Braun designed right there in Huntsville, Explorer 1 had discovered a new realm, named the magnetosphere in 1959.

Between that time and the beginning of the AMPS study, scientists investigating the magnetosphere had been analyzing the relationship between the sun, the solar wind, and auroral displays. "We had had tantalizing clues of a connection between the sun and the Earth," says David Reasoner, the NASA project scientist for CRRES. "As early as 1910 there was a large observation database that provided morphological description of the auroras. In the first ten years after Explorer 1, we had the gross overall model of the ionosphere and magnetosphere."

But basic questions about the near space environment remain. For example, scientists continue to disagree about the source of certain charged particles trapped within the Van Allen radiation belts. And no one has yet explained what makes auroral electrons accelerate to velocities ten times greater than the electrons spit out by the sun.

Charles Richard Chappell, an AMPS member and now chief scientist at Marshall, thought that it was time to encourage more active observation. "Partly because the heritage is in passive observation, there has been more interest in passive experiments, and so there is limited funding to do active things," he says. "But active experiments fit nicely with the shuttle. The experimenter could be there running the experiments. We asked [the scientific community in 1973] for projects that would try to change the magnetosphere. They were never realized as a complete payload, but they were realized in pieces."

Veteran crew chief Jim Harrison has primary responsibility for the Thunder Chicken*'s maintenance.*

Lead scientist Eugene Wescott's computer displays a map showing the location of a CRRES release.

One of the pieces became an international project to create an artificial comet using barium (see "The Barium Bomb," p. 58). Another will fly this August, when the shuttle *Atlantis* extends a 12-mile tether to test the effect of an induced electrical field on the surrounding ionosphere. NASA put the remaining experiments together with an Air Force project to study the effects of radiation on satellite electronics and in 1982 created CRRES, a yearlong, $80 million program involving sounding rocket releases from Puerto Rico and the Kwajalein Atoll in the South Pacific, a small satellite orbited by the Pegasus rocket, and three series of experiments based on satellite releases.

"We realized that all the systems [solar wind, ionosphere, and magnetic fields] were coupled," says David Reasoner. "One way to study coupling is to make a perturbation somewhere. Like any electrical system, if you kick it and study its response, you can understand the system."

Eugene Wescott of the University of Alaska Geophysical Institute had been kicking the ionosphere for years when he saw the 1973 AMPS announcement. Tall and striking, with long white hair that reaches the middle of his back, Wescott was already a world-class expert in the use of barium charges when he was named one of 19 principal investigators in the CRRES program.

Wescott became aware of the mysterious power of geomagnetism while working on ground surveys for what was once the Atomic Energy Commission. "My background was in exploration geophysics, looking for minerals and whatnot," says Wescott, who speaks slowly in a deep voice a little like John Wayne's. "One summer up in the upper peninsula of Michigan we were running a magnetometer survey for structures. We were looking for uranium, actually. It turned out all the data we got one day was just garbage. And that evening there was an auroral display and I hadn't seen one since I'd been a small child. So I said, *Hmmm, I bet there's some connection between our magnetometer garbage and the aurora.* But I didn't really get into the upper atmosphere until the Germans came up with

the barium technique. And as soon as I heard about it, I said, *Ho—this is the way to investigate the aurora.* It's like tossing aniline dye into the ocean."

Magnetic fields exert a force on any electrically charged particle. Barium ions carry a positive charge, and the magnetic field surrounding Earth forces them to line up along the field lines. In small amounts, barium and the other metals act as tracers, "dyeing" the field by creating purple streaks in the sky where the field lines are.

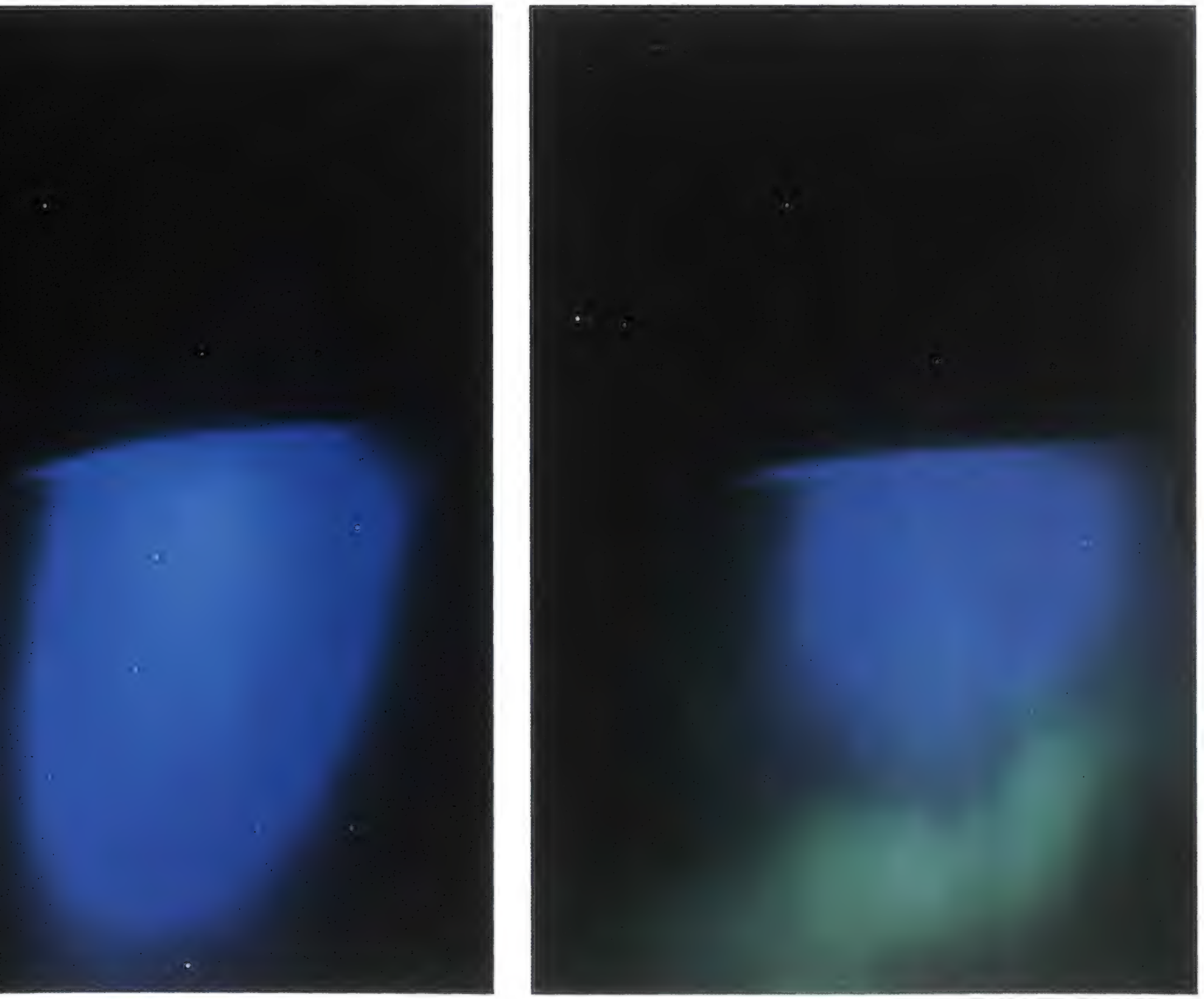
But in larger amounts chemicals can actually modify the space environment. A sudden energetic burst of electrons and charged particles in the ionosphere in some ways mimics the effects of a solar flare, which blows hydrogen nuclei and electrons at Earth's magnetosphere. Scientists can study some of these solar effects during a natural aurora, but by initiating the disturbances they can control the situation and make repeated measurements. Wescott has disturbed the ionosphere with sounding rockets launched from Virginia, Hawaii, and Alaska. In Peru, he became the first scientist to throw a strontium bomb at the magnetosphere. He designed the charge himself.

In 1971, Wescott and Hans Stenbaek-Nielsen, a Danish geophysicist, launched a barium charge from Hawaii to demonstrate the technique for tracing field lines. While analyzing the data at the University of Alaska, they found that

To see as the research team sees, hold these two pages open and raise the magazine over your head. The predawn sun is ahead—east—and CRRES is streaking overhead from behind you. In the first photograph, a barium canister has just exploded near the center of the frame, and a cloud of neutral barium atoms, glowing green, speeds sunward at orbital velocity; the cloud continues to spread in the next two frames. Sunlight strips electrons to form barium ions, which glow blue-violet. Some ions take off along magnetic field lines—the streak at the "top" of the cloud—which are aligned with the planet's poles to the left and right. Hans Nielsen (left) and Gene Wescott followed a trail of ions in 1971 and found a puzzling break in the magnetic field.

the movement of the magnetic field around Earth was greater in the south than in the north. The two ends of the field lines had somehow become disconnected—a "non-conjugacy." Wescott and Nielsen's paper describing these results was received with some skepticism because no magnetic field line can simply terminate in empty space. Even the authors were baffled. So they returned to Hawaii the following year and tried it again. But this time the movements at the two ends of the field were the same—no non-conjugacy.

"So we've been sitting puzzling over that for all these many years," Wescott recalled in his hotel room in Aruba. "The field line from Hawaii to Samoa is fairly short. It only took about like 12 minutes for the ions to go from one end to the other. We tried to do one from



MORRIS PONGRATZ, LOS ALAMOS NATIONAL LABORATORY

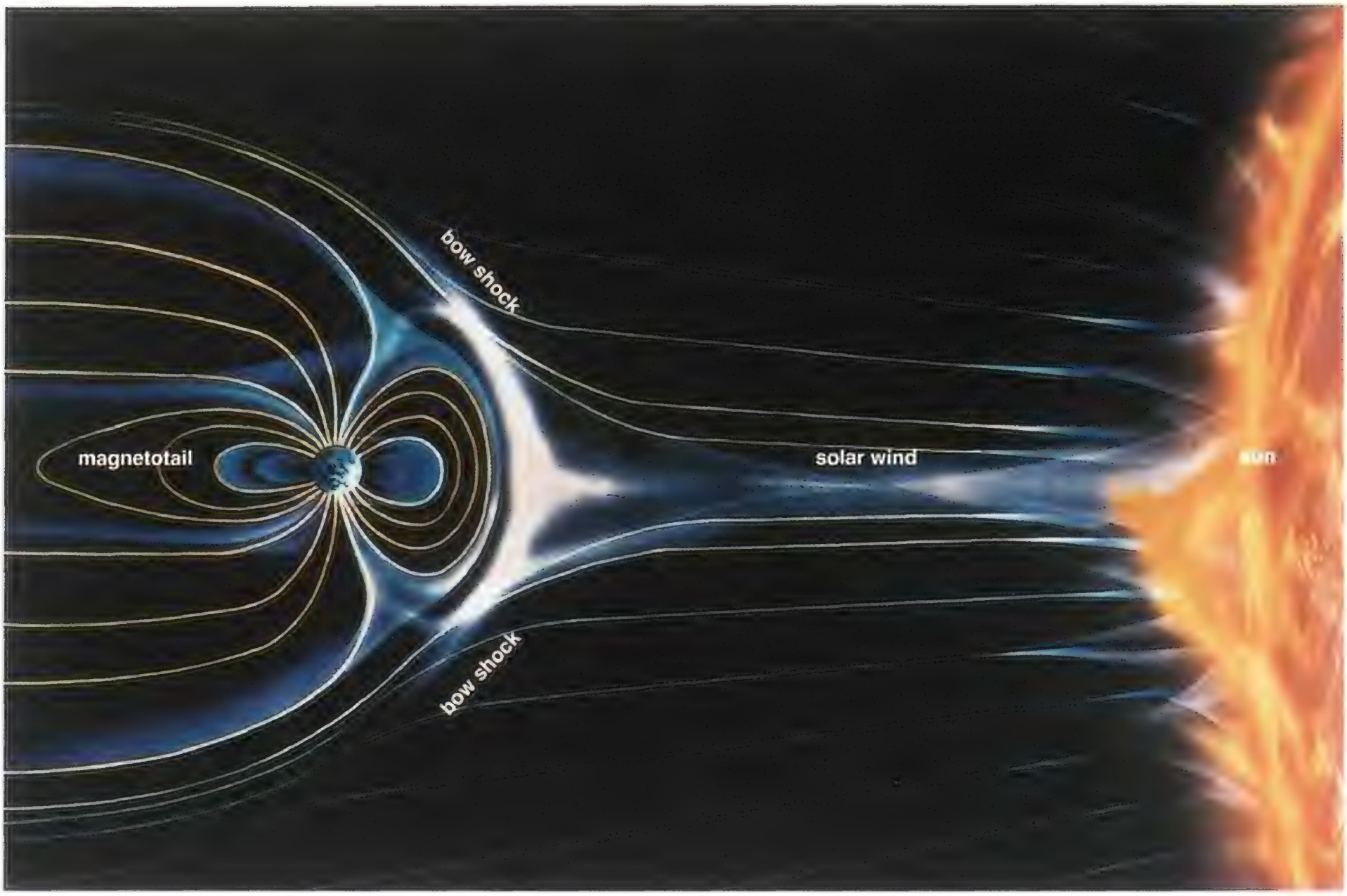
Fairbanks—Poker Flat—to Antarctica. And there the field line is extremely long and it takes about an hour for the ions to get from Fairbanks to the south. And although we had aircraft flying around south of New Zealand to look for the ions, even a fairly small electric field would move the ions a thousand kilometers east or west, so there was no chance that it really worked. The ions I'm sure got there. We weren't looking in the right place."

Wescott's experiments in the early '70s were limited. "We did it fairly blind," he admitted, "so we can only guess at what the ionosphere really was doing. We know that it was very quiet on the day that we had the non-conjugacy.... But here [at Aruba] we have instruments on the satellite, we have [the radio telescope at] Arecibo, we have ionosondes in South America and magnetometers. It isn't a complete set—I mean, I could wish for a lot more—but it's going to give us a lot more information than we had in 1971."

A whole lot more: NASA set up 11 ground sites for instruments in the Caribbean and South America. Besides the two KC-135s, the Boeing 707 Airborne Observatory of the Argentine Space Agency would be collecting data to the south. Wescott would be watching from the *Thunder Chicken*.

At the Aruba observation site, Michael Mendillo, Jeffrey Baumgardner, and Daniel Nottingham, all astronomers from Boston University, would set up a charge-coupled device (CCD) image-intensifier camera with a filter that would screen out all photons but those from barium neutrals and ions. Mendillo and program scientist Rick Howard had scouted the island for a dark, isolated area with enough electrical power to run the instruments. They found a site at the top of a tiny mountain near a phone company receiving tower, a small power station, and a scraggly herd of wild goats.

Morris Pongratz of the Los Alamos National Laboratory, Wescott's co-investigator on the first Aruba release, would be watching from St. Croix with three film cameras, two television cameras, and a CCD camera. Pongratz was studying the behavior of the plasma in the first few seconds of ionization in order to describe how the cloud's initial momentum and energy resolved into a state of equilibrium with the surrounding ionosphere. High-resolution, low-light



camera systems were also being set up on Bonaire, an island close to Aruba, and on Guadeloupe, St. Thomas, and Puerto Rico. The scientists would measure the relative amounts of barium ions and neutrals and model the impact of the hot barium plasma rushing through the ionosphere. In past experiments observers had identified a "snowplow effect," as Hans Nielsen called it. "The dense cloud of barium moving at ten kilometers a second will simply push the background atmosphere out of the way," Nielsen explained. This time they would be watching to learn how the barium ions are slowed and what happens when they collide with oxygen atoms.

The number of Caribbean sites was a hedge against bad weather. Readings from at least three places were needed in order to fix the precise location of the event, and cloud cover could take any site out of the game. The two aircraft would be able to top any clouds below 40,000 feet.

On the previous day, Rick Howard had called a press conference to tell local reporters when and where to look for a strange greenish glow about as bright as a full moon and to explain what NASA was up to. "The satellite is in a repeater orbit," he said. "Every three days it comes back to the same position, and that's when we can do the releases. The satellite must be in sunlight and the ground sites in darkness."

The Air Force Consolidated Space Test Center (CSTC, pronounced "C-Stick"), which operated the satellite from Onizuka Air Force Base in Sunnyvale, California, had adjusted its orbit so that its perigee walked westward at a rate that synchronized the release times with the sun, which was rising a little later each day. Between July 10 and 25, the moon would be down as the sun was rising; after that, the moon would be up and the sky too bright until the following month. The releases had to be timed so that the satellite's direction—and therefore the direction of the barium cloud moving with it—would be nearly perpendicular to the magnetic field. As if that weren't enough, the scientists were also hoping the density of electrons in the ionosphere was not too high. This experiment was beginning to echo President Kennedy's words extolling the Apollo program, when he said we undertake space voyages "not because they are easy, but because they are hard."

Interaction between the sun and Earth is dynamic, but the anatomy of coupled forces is immutable.

Around midnight scientists and flight crews arrived at the airplanes. The second KC-135, named *Aurora Explorer,* seemed a little more buttoned down than the *Thunder Chicken.* An oxygen mask had been carefully placed on each seat, and the cabin, though packed with instruments, was neat as a pin. The airplane had been assigned to the Air Force Geophysical Laboratory's ongoing study of the aurora (see "The Aurora Patrol," February/March 1989), flying out of Hanscom Air Force Base in Massachusetts for the 15 years Joe Tyler has been its crew chief. It had an all-sky camera, ionosondes, and a coffee maker that had been installed with duct tape. All three were essential tools for studying the polar aurora, according to Ed Weber, a scientist who has been with the airplane almost as long as Tyler.

Eugene Wescott stood in the open

hatch of the *Thunder Chicken,* white hair blowing in the warm wind. He was silent for a while, perhaps contemplating the decision that he and Morris Pongratz would soon be facing. "There's always a lot of pressure to go," he said suddenly. "You know, it's expensive—three airplanes and everything. They always want you to push the button." Field science is not for wimps.

The satellite would eject a canister at 4:35 that morning unless it received a command to abort—that way, a signal failure couldn't botch a release. NASA had set up a communications network, something that NASA is still very good at, connecting all the ground sites, the airplanes, David Reasoner in Huntsville, and the satellite's command and control center in California with Rick Howard and NASA logistician Andy Cameron at the Aruba airport tower. CSTC got a clearance from North America Aerospace Defense Command at T minus three hours, at which time the team began polling the sites every half-hour. Based on a final poll, Wescott and Pongratz would have to make their decision by 4:04. CSTC liked to have a few minutes in the event it had to tell CRRES to hold its powder.

At 2 a.m. the *Aurora Explorer* took off for its run, which would begin north of Hispaniola. A half-hour later the *Thunder Chicken* headed south.

Starlight and a very faint glow from two television screens barely illuminated the figures on the Aruba mountaintop. It was too dark to see the goats, but you could smell them. A plastic tarp had been lashed to the fence to block headlights from any car that chanced to head up the steep switchback, which in places faced the cameras. The tarp slapped loudly in the wind.

Michael Mendillo stood in the midst of a network of cables with his back to two telescopes mounted on tripods and looked toward the sky in the east. "What do you think, DuWayne?" Mendillo asked DuWayne Bostow, an explosives expert from the Geophysical Institute in Fairbanks. Bostow machines the barium charges for sounding rockets, but that night he was responsible for recording the explosion with the institute's CCD camera. "Looks good," Bostow answered.

Mendillo donned a headset. During earlier polls, various scientists had reported problems. One of the most serious was an electrical glitch at Guadeloupe. Bonaire was completely out of the picture; the scientist was still waiting for her equipment to be delivered. An airglow filter was not working in Puerto Rico. Finally Mendillo spoke into the headset: "The situation in Aruba is good, but we have some low clouds."

On the video screens, small squares of sky were sprinkled with bright stars. A cloud had showed up, and someone asked Mendillo how the latest poll had gone. "There's nothing at Bonaire," he said. "At Guadeloupe they're electrocuting themselves. And, uh, Bernhardt doesn't have his airglow filter." It was 3:30 and the wind was unrelenting. There was some frustration in Mendillo's voice. The group watched the sky

Ions in the Dark

Some of the most fascinating experiments in CRRES tested a theory of physical processes that occurred before Earth was formed. In 1954, Hannes Alfvén, a Swedish physicist who had won a Nobel for pioneering work in plasma physics, published *On the Origins of the Solar System,* a book that suggested that the planets had formed from gases being pulled inward by the long reach of the sun's gravity. If a gas atom became ionized by the sun's magnetic field, its motion *across* the field would be halted before it fell into the sun. Alfvén theorized that such ionization occurred as the gas crossed the magnetic field at a certain characteristic "critical ionization velocity" (CIV). The ionized gas was trapped, he wrote, "at certain distances which roughly correspond to the present situation of the main groups of planets."

According to the theory, elements would accelerate as they approached the sun. Hydrogen and the lighter gases, which ionize at lower velocities, formed the outer gas giants. Elements that had to achieve higher velocities to ionize—nickel, iron, and other constituents of the inner planets—fell in closer. Eugene Wescott calls it a "neat theory" that needs to be tested in space, "which is about as close as you can get to the original solar system. And it turns out that if you take all of the mass of the planets and their atmospheres, and you equally distribute it from the sun on out to Neptune, you would have about the density of one of these barium releases that we do."

CIV experiments are done on the night side of Earth to prevent the atoms from being ionized by sunlight. In 1980 a group from the Max Planck Institute launched a barium charge over the Sahara Desert when the ionosphere was teeming with electrons and produced a high yield of ions. Wescott and Hans Nielsen tried several times to duplicate that experiment but were unable to obtain ionization. "Apparently the high electron background density is a requirement," Wescott says. "All the other experiments we did which produced nothing were at fairly lower background density.... So that's why we went to the South Pacific, because we could get the high electron density. There the satellite orbit was in the southern hemisphere near perigee at dusk, and that's where you would get the highest electron density—just after dusk. The sun shines on the ionosphere all day making electrons. Then as the sun sets they begin to fade away. By dawn you're down to the minimum."

"Over the years we had tried almost everything else," says Nielsen. "But it takes a lot in science to establish a cause and effect. You know, the stock market goes up and you observe that the sun is active. Are the two related?"

Wescott and Nielsen wrote that they observed a CIV process following a 1986 launch—that neutral barium had become ionized by its energetic movement across Earth's magnetic field, just as Hannes Alfvén said it would. But some Lockheed scientists disagreed, contending that the ions were created by a charge exchange during collisions between barium ions and oxygen neutrals in which the barium ion takes an electron from the oxygen. This argument assumes that such an exchange would occur in a higher number of collisions than Wescott and Nielsen are ready to accept. One of CRRES's Caribbean releases was timed to go off in Earth's shadow. Both sides were hoping it would give them more ammunition.

Mike Mendillo's team mounts a dead-of-night vigil in blackness broken only by a video screen's glow.

and waited for the last poll.

Finally, Mendillo called out the results: "Scrub." The tarp flapped. Nobody said a word. "Scrub," Mendillo repeated, as if to confirm the idea to himself.

The reports from the ground sites had been bad enough, but what made Wescott and Pongratz decide to abort was the news that a spectrometer on the satellite had stopped working. "You always ask yourself: 'Is there a reasonable chance that I'll get something better?' " Hans Nielsen said later. "That weighs heavily. Then there's the second-guessing. There are a lot of people that suffer afterwards because of the Monday morning quarterbacking." After the scrub, discussions among the scientists grew contentious and Rick Howard had to referee.

Three days later everybody was back at the airport. John Wolcott from the Los Alamos National Laboratory showed up with what looked like a beer cooler. The container actually held a Xybion television camera, which Wolcott had been storing in his hotel refrigerator to protect it from the Caribbean heat and humidity.

It was hot inside the airplane, but at 30,000 feet they'd need the insulated jackets slung on the seats. Captain Jeff Laughlin made his way from the cockpit through the cabin, where technicians, crew, and scientists were all stepping around one another, to tell Lieutenant Timothy Heywood, the Air Force program manager, that number 131 was headed back to base. As it had three nights ago, the *Aurora Explorer* had taken off 30 minutes ahead of the *Thunder Chicken.* Laughlin had been listening to the tower frequency when the pilot reported an engine fire and alerted the controller that he was coming back in. Ten minutes later Hans Nielsen, who had been on the *Aurora Explorer,* climbed into the *Chicken* and confirmed that there would be only one airplane on the night's mission. The *Explorer* had landed safely but the engine problem required parts from Wright-Patterson. Gene Wescott looked out a window and said dourly, "I don't see any flames." Then he asked Nielsen to stay on board and help with the observing run on 127. At 3:31 a.m., the *Thunder Chicken* departed for Venezuela, doing its crew chief proud.

The loss of one airplane was troublesome but not critical because the ground sites were almost unanimously reporting good conditions. The exception was Aruba, where the astronomers could see only clouds. But the *Thunder Chicken* had cleared the cloud deck, and the starfield on the video screen in front of Gene Wescott was wondrously clear.

Next to Wescott, Heywood balanced a small laptop computer, its display showing the coordinates of the airplane based on Global Positioning System satellites. Unwilling to wait for the satellite navigation hardware to be installed,

Heywood had rigged a receiver and written some software to translate the GPS signals into the information on his computer screen. The top of his display read "Aurora Reggae."

At 4:05 Rick Howard polled the ground sites for the last time; Wescott and Pongratz decided to go. "Everybody—look for the satellite to show up on the video screen, and point it out when you see it," Wescott announced. The airplane was completely dark except for the glow from various screens. Every few minutes Tim Heywood called out the time, starting at T minus 12 minutes. At T minus three, Wescott said, "Can I go to the bathroom now?"

In the final seconds before the release, Hans Nielsen moved to the arm of Wescott's chair. Both of them stared at the video screen. "There it is!" said Nielsen, springing forward. A small bright disk sailed into the starfield from the upper left—a robot with an appointment to keep. In a few seconds the barium burst into a perfectly round cloud. "Bingo!" shouted Rick Reardon, a scientist from Lockheed. Reardon was watching a screen in the aft fuselage, where he was using an interferometer to measure the velocities of the ions. The ions were already lining up along the magnetic field lines—distinct streaks were forming.

Wescott was trying to follow the motion of the particles along the field lines. Operating a joystick with his right hand, he continually conferred with Nielsen:

Rollout roulette: as a diversion, the crew bets on which nosewheel number will come up at shutdown.

The ground team, (from left) Mike Mendillo, Dan Nottingham, and Jeff Baumgardner, check their hill by day.

"Up? To the right? The other way?" Wescott's camera tallied ions for the next half an hour.

The computer screen linked to John Wolcott's Xybion camera had blinked and gone blank a few minutes before the release. Wolcott, who was looking for signs of collisions between oxygen atoms and electrons, had calmly tried to bring it back, but with no success. Once the excitement of the release had subsided a little, Wescott asked, "John, did you get anything at all?"

"No, Gene. Nothing," Wolcott answered. "I don't know what happened." (Wolcott would later discover that a temperature-sensitive resistor had overheated. "We had a full data set anyway," he said. "By that time the airglow filter on the ground was working.")

Only a few minutes after the conversation over the Xybion, Rick Reardon began screaming again from the back of the airplane. "I don't believe this! My computer crashed again!" he ranted, threatening several times to throw the machine off the airplane, all to no avail. He had managed to collect data from the first few minutes of the release, however.

Starting that night, the CRRES program was on a roll, popping canisters during four of six windows (pairs of canisters were fired in two experiments). The most difficult part, however, still lay ahead, as the scientists returned to laboratories and universities to make sense of the data. Early indications are that there was conjugacy in the field between Antigua and southern Argentina and that no critical ionization velocity process occurred (see "Ions in the Dark," p. 63). Wescott told a meeting of the science working group at the Goddard Space Flight Center last October that he believed the velocity of the ions had been too great for the process to work, but he and his colleagues are still analyzing their data.

The American Geophysical Union, the group that published James A. Van Allen's first description of the belts of radiation surrounding Earth, devoted a full day's session of its 1991 fall meeting to the first wave of CRRES papers.

On October 12, during its 1,069th orbit, the CRRES satellite experienced "an anomaly"—it failed to respond to a command to turn on its transmitter. Although CRRES had no more canisters, the Air Force had been hoping to collect data from it. On December 3, the program was officially "discontinued."

By December, the 4950th Test Wing reported that the Thunder Chicken *had been relegated to surplus status—CRRES was the airplane's last mission. Jim Harrison plans to retire this August.*

Going With the Flow

Sometimes the only way to keep air traffic flowing is to stop it in its tracks.

by William Triplett

It's 6:30 in the morning on a spring day in Washington, D.C. Behind secured doors in a government office building on Independence Avenue, a dozen men wend their way around an obstacle course of desks stacked with telephone banks and computers. The windows are blacked out, the only light coming from desk lamps and monitor screens displaying radar tracks and satellite images. Six floors below the morning rush hour is gearing up, but in this large, shadowy room another kind of traffic commands attention.

As the smell of coffee laces the canned air piped in through a rumbling ventilation duct, the former air traffic controllers who staff the Air Traffic Control System Command Center, better known as Flow Control, gather for the morning weather report. It's the first event in a day spent coordinating, mediating, and arbitrating air traffic across the country, and the controllers have already loosened their ties and rolled up their sleeves. Today some 25,000 flights will take off from 55 major airports in the United States to become part of a vast and, it is generally acknowledged, overburdened system of mass transportation. It's up to the people in Flow Control to make sure that it, well, flows.

"It's sort of like being a referee at a football game," says Ralph Davis, a national traffic management officer, with a certain resignation. "You know going into it that not everybody is going to be happy with your decision. Even if things turn out exactly like you called them, somebody always says 'See? I told ya!' There's some frustration about that.

Flow controllers work in the dark so they can read the computer and radar screens that enable them to coordinate the nation's airways. Air traffic manager Ralph Davis (left, above) and National Weather Service meteorologist Denny Politano spend much of their time making sure that traffic flows even in nasty weather (opposite).

but you know that based on the data you have, you're making what you think is the best decision you can at the time. Which is all you can do."

Airlines come and go, but the skies have never been the same since the arrival of the commercial jet. One byproduct of the Jet Age was the need for a coordinated nationwide air traffic system. Back in the propeller era, air traffic was mostly a local affair, with each of the 20 air traffic control centers around the country responsible for guiding aircraft through its territory. "None of it was really organized in any centralized fashion back then," remembers Jack Ryan, formerly head of air traffic operations at the FAA and now vice president of air traffic management at the Air Transport Association. "I used to work in the Washington [ATC] center," he says, "and if I had too many planes I'd just call New York center and tell them to hold the traffic."

That practice—imposing restrictions on neighboring centers to keep one's own airspace manageable—increased as the skies grew crowded. New York would tell Cleveland to feed in all airplanes with maybe an extra 40 miles of airspace between them, known as miles-in-trail. But Cleveland would then impose 50 miles-in-trail on Chicago, which in turn would pass on 60, creating a coast-to-coast domino effect that eventually resulted in excessively delayed takeoffs across the country.

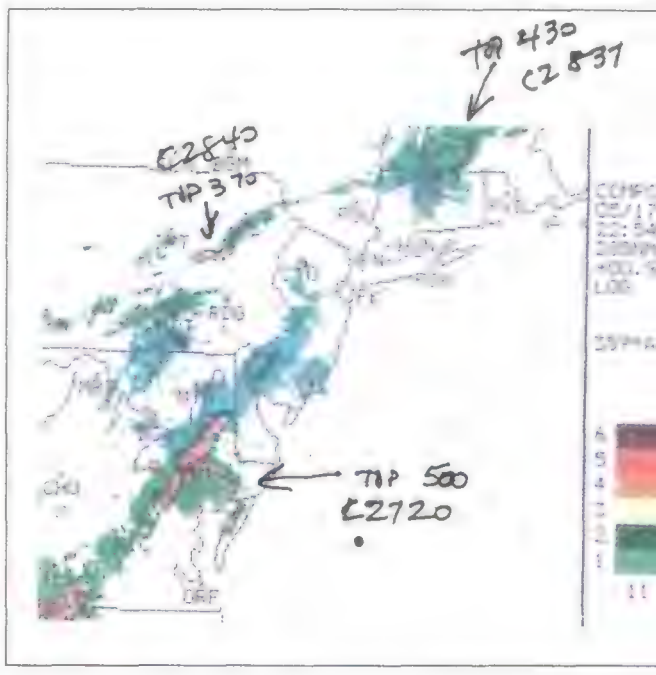
It was a system with potential for descending into chaos, so on April 27, 1970, the Federal Aviation Administration established Flow Control. Predictably, the ATC centers were resentful. "Nobody wanted Big Brother looking over their shoulder telling them what to do," explains Sid Wugalter, a former national traffic management officer.

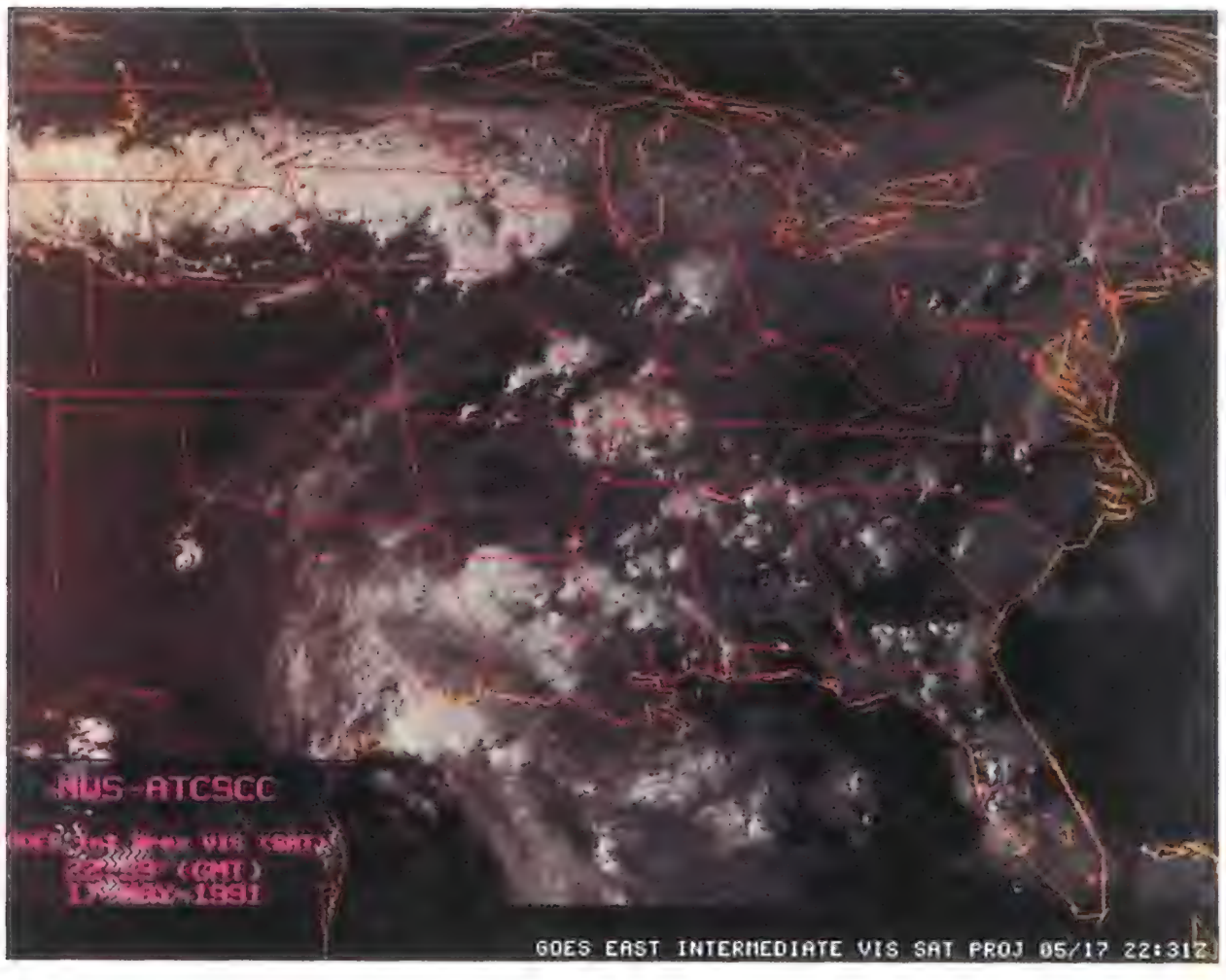
Tensions increased in 1973 when the OPEC oil embargo jacked the price of fuel through the stratosphere. Jets burn lots more fuel in the low altitudes typical of holding patterns. The airlines groused to the FAA that the fuel costs of in-flight delays were killing them. The government decided it was cheaper to hold airplanes on the ground than to keep them waiting in the air. "Flow Control really started out as a fuel management program," says Davis.

Ground delay programs were first tested at Chicago's O'Hare and Denver's Stapleton airports in 1974. They proved successful and were later expanded for system-wide use in 1979, but few of the ATC centers offered any congratulations. "There was still absolutely no respect for Flow Control," says Wugalter. "The centers thought the guys in Washington really didn't know what they were doing."

As a result Flow Control was often left out of the loop. Its equipment was fairly primitive, and because the ATC centers often neglected to inform Flow Control of new developments, like changes in the jet stream's velocity, the office often ended up playing a minor role. "We might ask or suggest things to the centers," says Ryan, "but for all practical purposes we were really just an advisory service."

One particularly bad night occurred in 1975 at O'Hare. "Unbeknownst to us the jet stream was coming in about 50 to 80 knots stronger than usual," remembers Wugalter. "As a result traffic coming from the west arrived almost a full hour ahead of schedule. Traffic from





NATIONAL WEATHER SERVICE (2)

Thunderstorms depicted in the GOES satellite photo at left impelled flow controllers to write ground delay programs for eight airports when storms stalled over the busy northeast air corridor one day in 1991. Radar images and color codes indicate the intensity of individual disturbances (above). Rerouting around severe thunderstorms can cause long delays on the ground (right).

the east arrived about 45 minutes late. They all arrived together about 2 p.m." He pauses, then with a laugh adds, "We had a little problem."

Some 180 airplanes went into holding patterns. Those low on fuel put down at alternate airports. Some even refueled at other airports, then flew back to Chicago to re-enter a hold. Pilots were tense. Controllers were tense. Passengers were angry, scared, or both. "It was just awful," says Wugalter. "We had airplanes all over the place, and it stayed like that through the night. We never recovered until the next day."

Things changed for Flow Control in August 1981, when more than 10,000 striking air traffic controllers were fired by President Reagan for walking off the job. The centers, gutted by the strike, turned immediately to Flow Control for help—and Flow Control came through, keeping nearly 70 percent of normal traffic flying, nearly double even the most optimistic expectations. It was a dramatic demonstration of just what a centrally coordinated air traffic system could really do. In practice as well as in theory, Flow Control was now in charge.

And there's a lot to control. Last year 450 million passengers made some 5.28 million flights. In the early days a flow controller used to get a picture of en route traffic by scribbling down radar plots phoned in from the ATC centers and maybe putting them on a chart or map. But in January 1987 Flow Control acquired the Aircraft Situation Display, which delivers a near real-time picture of the entire air traffic system. "For the first time you could actually see what was happening in the system in real time," says Ryan. "Before, you had to rely on [after-the-fact] phone calls from the centers. But even then you still couldn't see it. The ASD is the major turning point in how Flow Control could be used."

Relying on radar and computer data from the ATC centers, the ASD tracks as many as 4,000 aircraft flying within the United States at any given time. It plots their progress on large monitors located at opposite ends of the Flow Control office, but the system is also available on each controller's computer monitor. Concentric circles, known as range rings, make it possible to measure the precise distance between airplanes and centers and ensure that air traffic stays properly spaced between airports. "The ASD is your eyes," says national traffic management specialist Gregg Dieboldt. "Without it you'd really have no idea how your program is doing in real time."

RANDY JOLLY

Unfortunately there's still no technology that can precisely call Mother Nature's every move, and it's usually the weather that wreaks havoc with Flow Control's careful plans. "San Francisco is almost always a trouble spot," says Bill Broach, a national traffic management specialist. "The weather is so uncertain there. Even the people in San Francisco have a hard time predicting when fog will lift." Another tough call is Denver, with its shifting winds. "That's probably the most difficult weather phenomenon we have to deal with," says Ralph Davis.

On this spring morning conditions around the country are fairly good, with some exceptions. "We've got a warm front in the south-central United States headed for the northeast," National Weather Service meteorologist Mike Szkil tells his audience of flow controllers. He sees possible trouble for the northeastern "Golden Triangle," particularly the New York City area, where three big airports—Kennedy, La Guardia, and Newark—might get socked

in with fog and low ceilings.

Newark gets particular attention because Szkil has noted that conditions there might deteriorate around 2 p.m. Thirty-five airplanes are slated to land in that hour—five more than Newark can handle under instrument flight rules. Worse, the weather could stay bad until 9 p.m., and demand for landings throughout the seven-hour period will continue to exceed the IFR rate.

To avoid putting arriving airplanes into holding patterns, Flow Control will have to thin the volume of traffic bound for Newark. This requires holding airplanes on the ground at their departure points, delaying their entry into the flow. What makes the call tricky is that the decision to hold airplanes will have to be made at least six hours in advance. Will bad weather really develop at Newark? Despite the wealth of available data, no one is sure.

It's already 7 a.m., and holding the reins this morning for Flow Control's East Complex is Rick Graves, a seven-year veteran from the Oakland, California ATC center. At 34 he's younger than most of the guys here. Like everyone else in this dark, cavernous room, he speaks softly because a normal voice level interferes with others on the telephone. And in Flow Control the telephone rules.

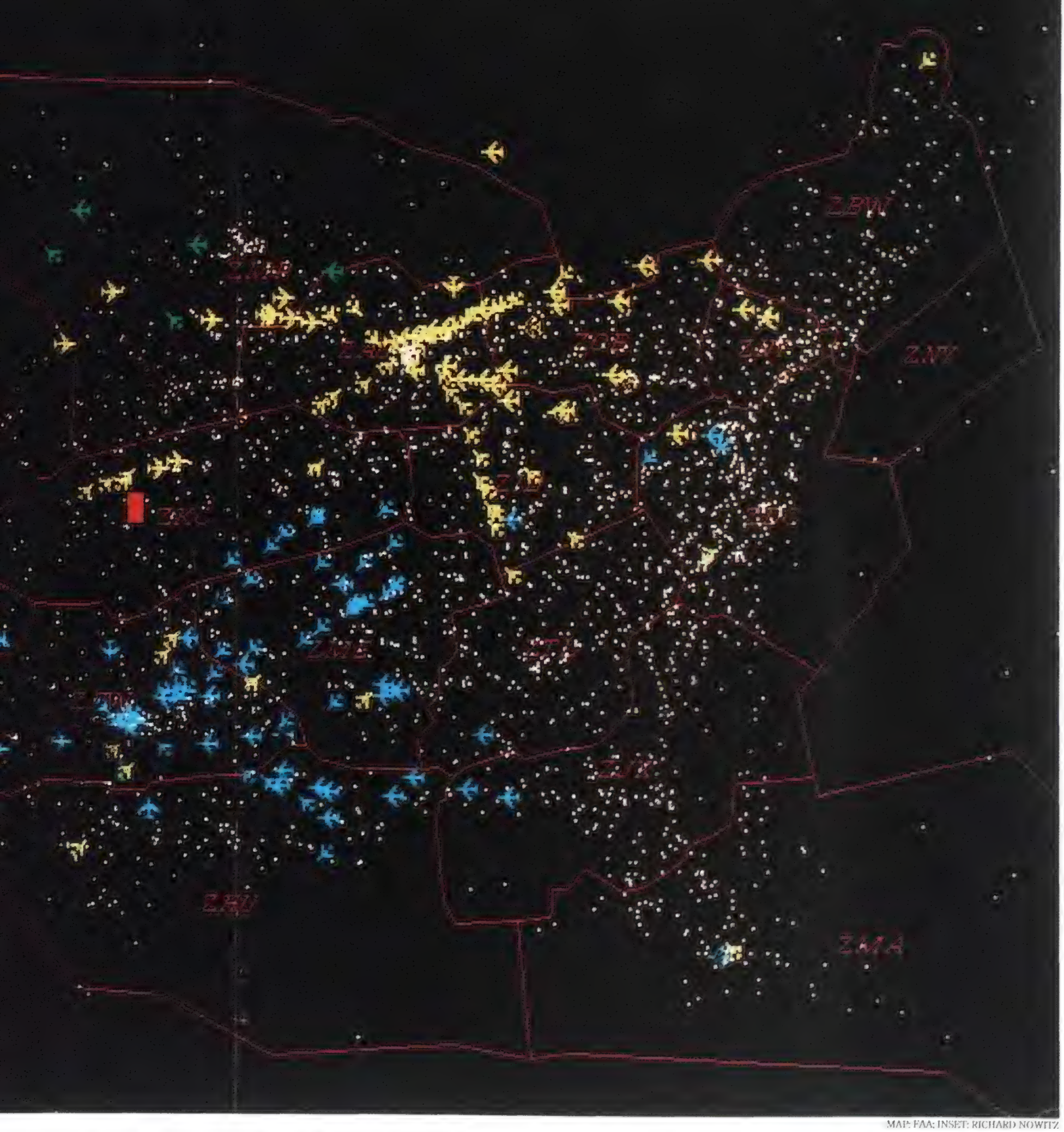
Graves returns to his desk chair and assumes the position: receiver in one hand, pen in the other, a blank yellow tablet in front of him. He punches the button on his console to get the New York ATC center on the phone for their opinion about the afternoon forecast for Newark. Looks pretty stinko, New York says, but they don't expect the worst to hit until two hours later than Flow Control's prediction. Graves then calls an airline meteorologist or two; they're not convinced the weather will hit at all.

Conditions like today's weather in Newark are always tricky to predict, but at least flow controllers have some lead time. Not so during during thunderstorm season, between April and October. These storms are usually local phenomena and the curse of air traffic controllers, who have to vector en route airplanes around them. "Thunderstorms tend to move very quickly," Davis says. "They normally don't affect us unless they pass over an airport, and even then it's usually gone in an hour."

When thunderstorms start acting uncharacteristically, however, they can turn a routine day at Flow Control into pure hell. "There've been times in the season when we could not get a single airplane through any part of Kansas City center's airspace for hours," says Arthur Lambert, a national traffic management specialist.

Last spring heavy storms formed a line from West Virginia's Blue Ridge mountains to Buffalo, New York. The

Aircraft over the United States appear in near-real time on the Aircraft Situation Display. Based on data from the 20 air traffic control centers, the ASD tracks as many as 4,000 aircraft at a time. Flow controller Arthur Lambert uses the ASD to his left to track aircraft as he checks the latest weather developments on the weather processor system (inset).



MAP: FAA; INSET: RICHARD NOWITZ

storms steamrolled east and then stalled directly over the busy northeast corridor. Flow Control quickly wrote ground delay programs for eight airports. Altogether 584 airplanes from every major carrier and commuter line were affected, some for as long as three hours, but the delay programs went into effect just in time to prevent a real mess.

This morning Graves has a little time to study his options. He can do nothing—and risk having Newark turn into a fiasco should the weather proceed to turn nasty. Or he can devise a delay program—and incur the wrath of the airlines should bad weather not develop.

The airlines tend to take a sort of Darwinian approach to traffic management, believing the system will always shake itself out eventually. "We lock horns a lot over the forecast," says Jim Coleman, a traffic management officer for TWA, whose own meteorological department often disagrees with Flow Control. Airlines are always concerned about passenger gripes and are especially sensitive about ground delay programs for hub airports, where scores of airplanes converge within short periods every day. One recent delay program for Kennedy tied up nearly 30 TWA airplanes. "The carriers get real testy about hub traffic," says Ron Haggerty, assistant manager of the traffic management unit at the Washington ATC center. "They'll always call and ask when the delays will be lifted, what kind of breaks they can get. We don't favor any airlines, but if we can help at all, we will."

On the other end of the spectrum are the ATC centers, which tend to be more

RICHARD NOWITZ

Rick Graves combines the skills of weatherman, air traffic controller, diplomat, and clairvoyant in his job as flow controller.

pessimistic about a forecast. They are also more likely to get their way because they're the ones who have to deal with the immediate consequences. "If a center is really insistent about their interpretation of the forecast for one of their airports, we'll usually defer to them," explains Bill Broach. "Just adding or subtracting six aircraft can make all the difference in the world," says Ben Rowe, a traffic management coordinator at the Washington ATC center.

"You always gotta negotiate with centers," says Lambert. "They'll always tell you they can't take any more traffic. So you say 'Yes you can' and ask how much miles-in-trail they need. They'll say 60, you say 30, and settle on 45."

The difficulty of the negotiations depends on the center involved, according to Glenn Godfrey, a national traffic management specialist. "They all have their own personalities. Some are glad to take on extra traffic. Others are a pain in the ass," he says.

As the clock rolls up to 8:00 a.m., Graves huddles with Szkil and others. The decision is made: Newark will go under IFR status at 4 p.m. local time. Graves will now have to devise a ground delay program by 11 a.m.

He has several options. It's possible to control the traffic volume by increasing miles-in-trail—assigning vector deviations or airspeed reductions to aircraft to space them farther than the usual number of miles that separates them.

If bad weather is expected for only an hour or two, a local delay program is probably best. Airplanes coming from distant airports can take off as scheduled because the weather will have cleared by the time they reach Newark.

But this morning the weather in Newark looks unrelenting, so Graves decides on a national ground delay program. He types the key parameters into his computer: Newark-bound aircraft scheduled to arrive between 4 p.m. and 9 p.m. Maximum allowable delay: 180 minutes. Stack value—landing slots left open for airplanes in the area when the program goes into effect: 12. Landings per hour: no more than 28. (The airport can handle 30 on IFR, but "somehow you never get less airplanes than you expect," says Graves.)

Within minutes the computer kicks out the ground delay schedule. Almost 200 airplanes will be delayed an average of 52 minutes. Graves calls the New York center and the Newark control tower and receives confirmation that a ground delay program is needed. As the clock nears the 11:00 a.m. cutoff, he transmits a national ground delay program to all 20 ATC centers, as well as the 10 major carriers and six commuter lines affected.

In airline terminals around the country, thousands of passengers will soon be groaning at the dreaded announcements ("We regret to announce the delayed departure of..."), but the delay is far better than the alternative. Tie-ups at just one hub airport can involve dozens of aircraft and thousands of passengers for one airline—numbers that increase exponentially when connecting flights are counted. "We're getting less passenger complaints now than in the days of airborne holding," says TWA's Coleman. "They haven't stopped, but they're doing it less."

At 11:40 the aroma of lunches heating up in the microwave begins to waft through the office. Graves has been fielding calls from airlines wanting to substitute flights in place of those that will experience long delays. No problem: he merely notes each on his yellow pad. Then another call comes in. Graves can see from the blinking light on his console that it's the New York center. He takes the call and in a few seconds his face has the unmistakable expression of someone who's just been told that all his work has been for nothing. The New York center has decided that the weather will be fine until 7 p.m.; they want to cancel the program. That means Graves will have to notify all the airlines—tell them: Hey, never mind, just kidding. "And I just talked to those guys before sending the program," he says, not without some exasperation. Diplomacy is an important asset at Flow Control.

Sure enough, the warm front fizzles before it gets anywhere near Newark, and the good weather holds. Tomorrow Rick Graves and the rest of Flow Control will go at it again with Mother Nature, the airlines, and the ATC centers. "Everyone wants us to be scientific, and we try as much as possible," says Bill Broach, his voice a mix of pride and frustration. "But it's more often an art."

Skylab's Untimely End

NASA

NASA considered it disposable. Now there are some who wonder if Skylab should have been recycled instead.

by James E. Oberg

Illustrations by Ben Juarez

Despite a rocky start, Skylab proved to be an effective space station. It fell to Earth in 1979.

It was one of the more bizarre proposals offered in response to the funding and design crises surrounding NASA's space station Freedom. In June a shadowy organization calling itself the "Center for Strategic Space Studies" suggested that instead of building Freedom, NASA should take the backup Skylab on display in the National Air and Space Museum in Washington and launch that.

The disgruntled NASA employees who suggested this idea did it anonymously, perhaps feeling that the space agency has come to enforce unanimity of thought not by encouraging superior ideas but by imposing bureaucratic discipline. And while many were quick to dismiss the proposal as impractical, it did briefly succeed in stirring debate throughout the space community. After all, with Skylab the United States once had a successful manned space station. Yet NASA let it slip through its fingers and fall to Earth in 1979.

In the late 1970s NASA had considered saving Skylab by sending an early space shuttle mission to boost it into a higher, more stable orbit, where astronauts could have studied how it had been affected by its years in space. Even more ambitious studies concluded that Skylab could have been repaired, reopened, and expanded. Had that happened, the history of the U.S. space program might have been very different. NASA could have begun the shuttle

NASA

Jack Lousma was a member of Skylab's second crew. He was later assigned to a shuttle mission intended to rescue the station.

program with an embryonic space platform, a destination to shuttle *to*. Experiments still in the planning stages in the 1990s might have been carried out in the 1980s, and NASA could have accumulated the experience necessary to advocate, design, and construct a permanent space station.

"It was a very serviceable, useful facility," recalls Jack Lousma, an astronaut who lived aboard it for two months and was later assigned to a shuttle flight that was supposed to rescue it. "It would have made a good follow-on set of missions, a nucleus for expansion."

That would have been a grand role for a spacecraft that started out as a modified propellant tank from a Saturn rocket's upper stage. Refitted as the Orbital Workshop, or OWS, the large tank was given two solar panels and a pair of small modules (an airlock module and a multiple docking adapter) at one end and a solar telescope assembly that swung out to one side. During 1973 and '74, a trio of three-man crews studied the sun and Earth from the space station on missions lasting 28, then 59, and finally 84 days.

For a time, though, Skylab's fate was in doubt. During the launch a meteoroid shield tore off, taking one of the solar panels with it. Then the other panel jammed, and the first crew had to make an emergency spacewalk to deploy it and save the station. The lost meteoroid shield was supposed to double as a sunshade, so the astronauts also had to rig up a replacement shade to bring the workshop's internal temperatures down to tolerable levels. It was an inauspicious beginning, but Alan Bean, who commanded the second mission, recalls, "It got better with time. More things were working at the end of the mission than at the start."

The station, never designed to be resupplied, was retired after the third mission ended on February 8, 1974. On the remote chance somebody else would venture aboard, the departing astronauts left a bag of food, clothing, film, and camera filters near the front hatch, tied securely to the telescope control panel. As they left the station, they removed the inside locking pin from the airlock hatch—in effect, putting out the welcome mat.

In the end, it was the sun that spelled doom for Skylab. The final crew used their Apollo spacecraft to nudge Skylab high enough to keep the station in orbit until sometime in 1983. But in the late 1970s solar activity intensified, heating and expanding the upper atmosphere enough to increase the drag on the space station. As Skylab's orbit decayed and its life expectancy decreased, the shuttle program encountered more and more delays. Early plans had called for the reboost mission to be undertaken on the sixth shuttle launch, but schedule pressures pushed it as far ahead as the second mission. However, STS-2 wasn't launched until November 12, 1981, more than two years after Skylab's charred remains had dropped across western Australia when the spacecraft fell on July 11, 1979.

Many at NASA were glad to see the end of Skylab. "It could well have been a snare and a delusion," says Joe Loftus, Johnson Space Center's advanced planning director. "It might have confused us, diverted us." That is, he elaborated, the energy expended on the rescue and repair mission might ultimately have been wasted, deflecting attention from more profitable investments in more promising projects.

Alan Bean disagrees: "I think we should have kept it up there. It wouldn't have detracted from anything. Maybe it would have had the opposite effect; we could have really demonstrated space station operations."

When plans to launch a second Skylab were scuttled in 1975, some preliminary thought was given to reopening the first one. With shuttle orbital missions due to start in 1979 and Skylab's orbit thought to be stable at least through the early 1980s, John Yardley, NASA's associate administrator for manned spaceflight, initiated a study to demonstrate what the shuttle could do on a Skylab visit. At the very least, the crew could attach a rocket stage to the station to ensure that when it did return to Earth, it would come down in an ocean.

Over the next year NASA worked to determine the likely condition of the aging spacecraft. Engineers at the Skylab project office in Huntsville, Alabama, and Skylab contractors such as Martin Marietta were convinced the

station would be in surprisingly good shape. More than just a handy target for a shuttle mission, Skylab was potentially a resource of great value.

Granted, the long exposure to space would have taken its toll. The hatch seals would have become brittle, gas pressure would have slipped (particularly within high-voltage components protected by high-pressure gas insulation), contamination would have built up on windows, mirrors, and filters, and mechanical parts would need lubrication. In addition, cosmic radiation and extreme temperature cycling would have degraded electronics and electrical parts.

But the wear and tear was in fact one of Skylab's most attractive traits. The information about effects of long-term space exposure would be vital to the design and construction of a new, permanent space station.

The engineers also catalogued the Skylab systems expected to be operable. These included refrigeration, oxygen/nitrogen distribution, carbon dioxide control (which used a molecular sieve more advanced than anything that has flown since), waste management, medical monitoring, trash disposal, ventilation, and the hatches (spare seals were aboard). The thermal control system would require servicing with cooling fluid. The power, communications, and data management systems would need augmentation. "All other systems should require minor flight activities for reactivation," concluded the final report to NASA headquarters.

Once safe in a higher orbit, Skylab could have become the focus of later space shuttle missions.

Of the 6,000 pounds of water launched in 1973, nearly 2,000 pounds remained (about 180 man-days' worth). "Probably potable, but may taste bad," the engineers concluded. No live organisms were expected, but the water "may be off color." Taste and color problems might make it useful only for washing (or, later, for electrolysis into breathing oxygen). The water system had valves within the workshop for eventual refilling.

There was an estimated 1,700 pounds (420 man-days) of oxygen in the tanks. Since the refill valves were near the airlock, it would be fairly easy for astronauts to replenish the oxygen during a shuttle visit.

The station's atmosphere did present one basic engineering problem for shuttle missions: Skylab's atmosphere was pressurized at 5 pounds per square inch, but the shuttle's was three times that, equal to sea level on Earth. An astronaut moving from the shuttle to Skylab would have to undergo three hours of pre-breathing in a transfer chamber to adjust to the change. Skylab's workshop could later be raised to 15 psi with no safety problems, but the airlock module and its extravehicular activity hatch could tolerate only 8 or 9 psi. Either these small modules would have to be replaced (or lined with a flexible airtight inner layer) or shuttle pressure could be temporarily reduced, as it is today prior to EVA. And off-the-shelf shuttle equipment would need extensive modification to be installed in the old station. Merely getting it aboard would have been a problem: Skylab's hatch was only 30 inches in diameter—half the size of the shuttle's.

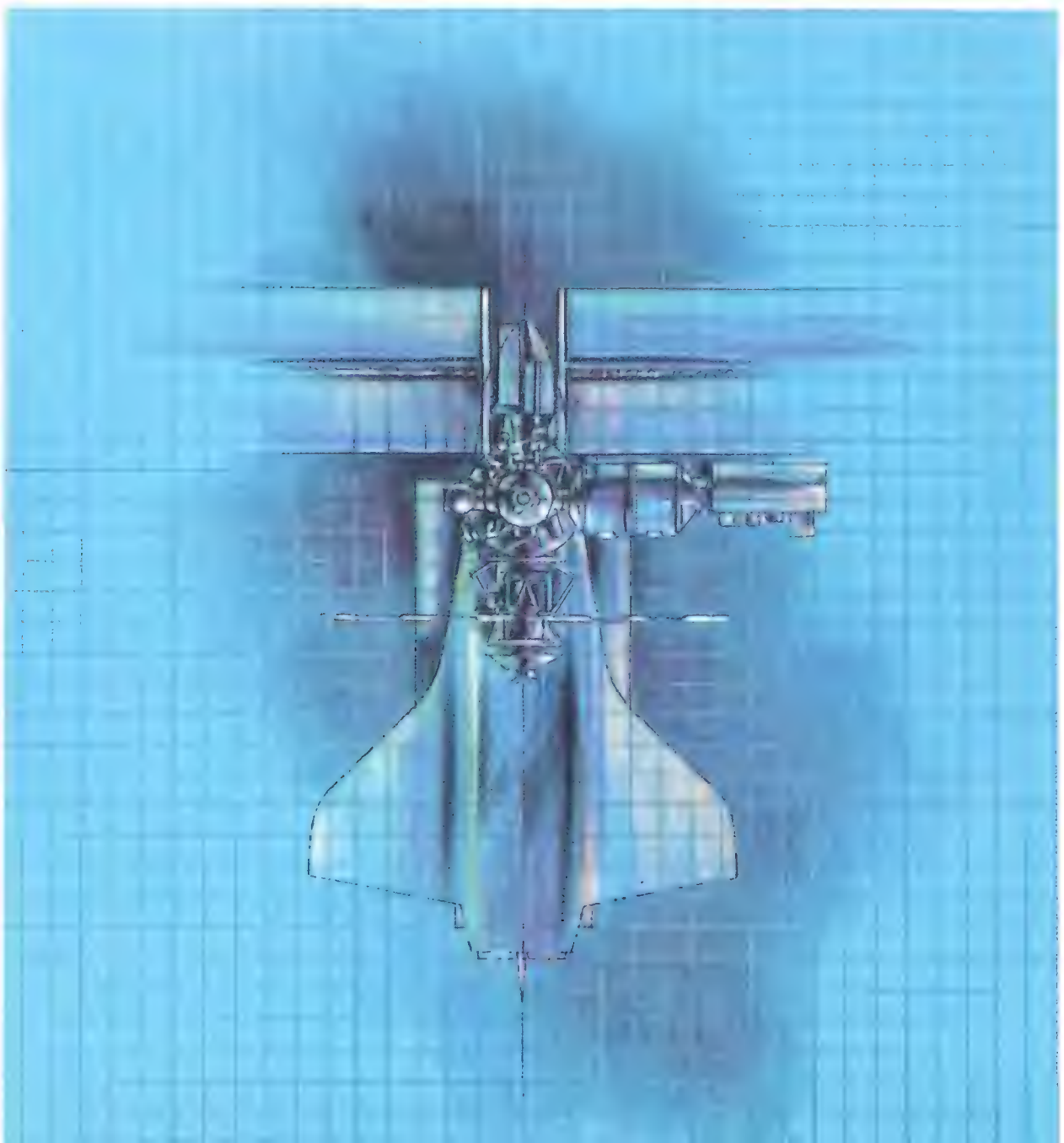
Although only a third of Skylab's trash tank had been filled, the latches on the trash airlock had jammed. Alternate systems would probably be needed. But microbiologists were excited at the prospect of studying microbes that had been reproducing in the trash for hundreds of generations in a spacecraft. They also expected to find interesting fungal spores on the walls and in the air (something not expected to excite visiting astronauts).

Skylab's communications system was operable but already obsolete. The shuttle would use higher frequencies than Apollo missions, and already the old ground sites were being phased out. New monitoring sensors would eventually have to be set up in the station and shuttle-compatible radios installed.

Although the solar cells were aging and good for only a few kilowatts of electrical output, the power buses and batteries were in good shape for reactivation. More power would be needed, however.

Probably the most serious problem in reactivating Skylab would have been the state of the station's attitude control system. One of three momentum wheels necessary to keep the station stable had already failed, and the nitrogen supplies in the thruster system were low. They could be replenished, but that would require an astronaut with a manned maneuvering unit to get to the feed valves. The star tracker (a vital component for attitude control) had also failed.

On the plus side, Skylab rescuers would get their shuttle repair missions "free," since the rescue was considered a good exercise for testing the new spaceship's capabilities. And the needed power and attitude control could be provided by an unmanned vehicle already in development, the Power Extension Package.



The PEP was designed to be a space powerhouse, waiting in Earth orbit for those visits when the shuttle needed more electricity for missions with the portable laboratory it sometimes carries called Spacelab. Attracted by the hefty 25 kilowatts generated by the PEP's solar panels, the Skylab rescuers suggested attaching the PEP to the station and using its power, while the PEP's attitude control sensors and thrusters kept the station lined up properly.

In late 1977 NASA headquarters completed a four-phase rescue plan. During the first phase, shuttle astronauts would boost Skylab to a higher orbit to give it an additional five years of life. Various shuttle-based boosting techniques were proposed, including pushing (the off-balance Skylab structure would have been a huge dynamic challenge) and towing (on a cable). Martin Marietta started developing the Teleoperated Reboost System, a cluster of

NASA's rescue plans started with a teleoperated reboost system operated by a shuttle crew. Astronauts with manned maneuvering units could then begin to re-equip and resupply the station.

rocket engines that could be attached to Skylab. Astronauts Fred Haise and Jack Lousma were assigned to the mission and began training to use the TRS.

Once Skylab was high and stable, phase 2 would commence. Engineers would develop refurbishment kits with the necessary tools and parts, and shuttles would make two visits, during which astronauts would enter the station. On the first visit, scheduled for January 1982, they would attach a modified version of the docking adapter built for the Apollo-Soyuz mission. Then they would test the thermal control system, install valves for repressurization, and reactivate all power buses. During the second visit, in August 1983, astronauts would install thermal and electrical units, service the thermal system, and conduct more extensive inspections and checkouts to assess the effects of exposure on solar cells, insulation, windows, seals, paints, film, lubricants, and other materials.

In March 1984 the shuttle crews for phase 3 would attach the PEP to Skylab, refurbish the station's scientific equipment, and operate the station in both tended (30 to 90 days) and unattended modes. They could use the Apollo Telescope Mount (all it required was more film) and the earth resources experiments. Other simple experiments could be taken up and installed as well. When operations intensified, a large docking/interface module would be attached to the front end of Skylab, with ports for the PEP, the shuttle, and an additional logistics module launched full of supplies. Additional ports would also be available for Spacelab modules. The old Skylab would begin to expand, piece by piece.

Phase 4 would be a five-year plan of growth, with the addition of Spacelab modules and pallets and perhaps a construction platform based upon the shuttle's external tank. There was talk of eventually giving Skylab a larger power module (150 kilowatts) or a large dish antenna (or both) for radio astronomy or power transmission tests. Once modified to accommodate six to eight astronauts, Skylab could serve as a space depot, experiment hangar, general-purpose laboratory, and habitat for construction crews working on more advanced structures. Equipment for the first three phases was estimated to cost about $60 million, not including launch costs or the power module, which were funded from different budgets.

But NASA, fixated on the shuttle program, wasn't really interested. Neither were those who controlled the purse strings in Washington. "We met with

House and Senate staffers," recalls Joe Loftus. "In the end it was admitted that there was an argument to preserve Skylab, but it lost out to the fact of the high cost on immediate assets."

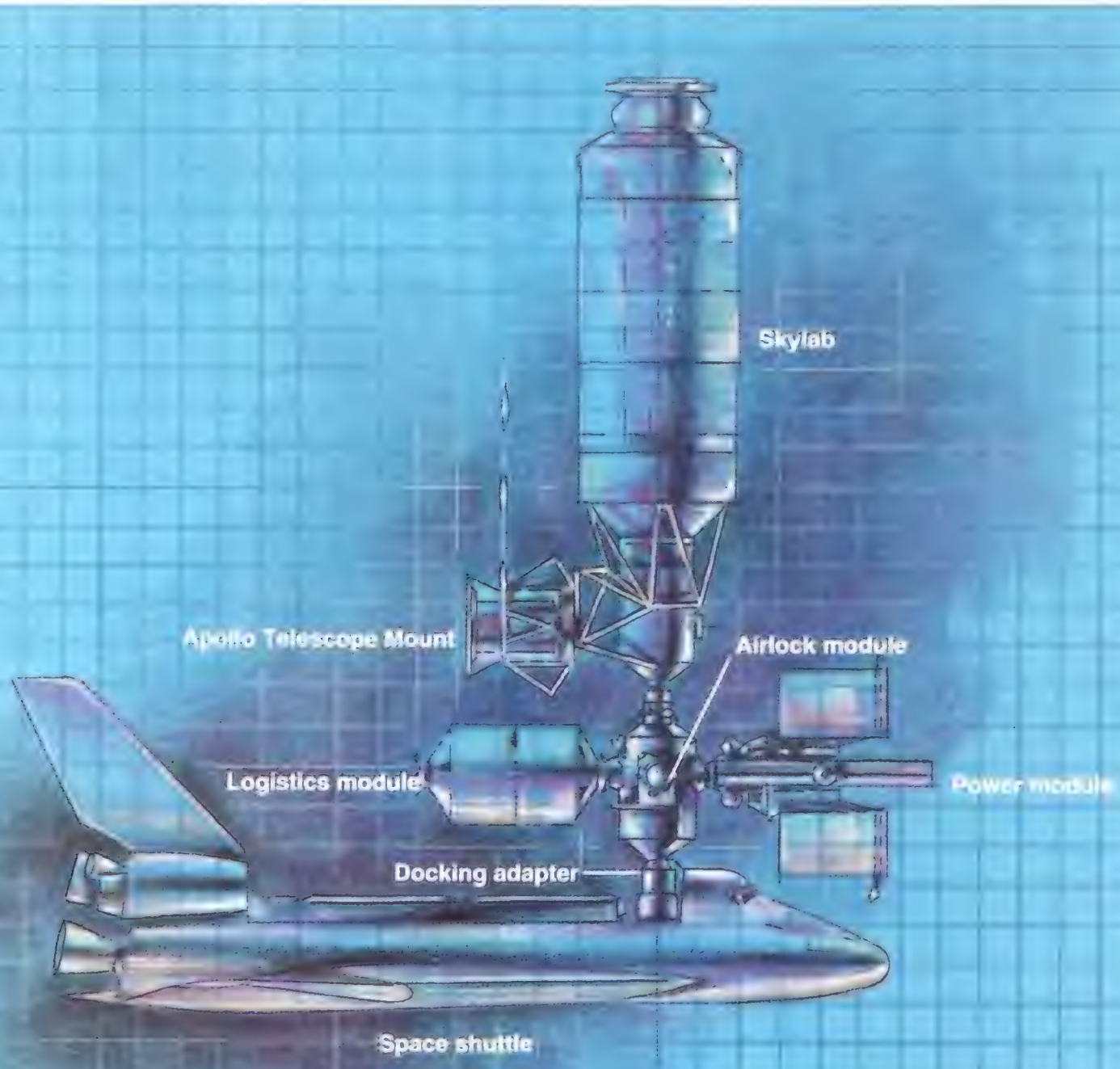
Besides, everything in the plan depended on getting Skylab boosted to a safe orbit, and that looked less and less likely as time passed. "It was nothing dramatic," recalls John Rivers, a NASA engineer who worked on the project. "But month by month the overlap between Skylab dying and the shuttle being born just dwindled into negative numbers."

As it became clear that a shuttle boost wasn't going to happen, alternate methods were considered, including expendable rockets. "We offered to fly [the TRS] on a Titan III," says Robert J. Molloy, the project's director at Martin Marietta. "That was seen as a bit self-serving, since Martin Marietta manufactured the Titan." It also would have taken two launches to get the entire booster into orbit. An Air Force Atlas Agena also might have done the job. Some even considered going to the Soviets for help, but their manned Soyuz clearly didn't have enough power. (An unmanned space tug named Cosmos-929 did, but its existence was a secret at the time.)

The main drawback to all the schemes, however, was money. All of them would have diverted funds that were needed for the shuttle. "It was certainly feasible," says Robert Aller, one of the Skylab's managers, about the rescue plans. "We were making some pretty good studies. It just cost more than we had ever considered."

The proposal finally died. There had been no obvious oversights, just a creeping conspiracy of circumstances that left a problem with no real solution. Besides, NASA had great hopes for a future beyond Skylab, one that included more advanced stations constructed from three or four space shuttle loads

The grandiose dreams for Skylab's future (below) finally came tumbling down to Earth. An amateur photographer captured the 77-ton spacecraft as a streak of light passing overhead a few weeks before its fiery end (above).



deployed in the 1980s. For some, Skylab's continued existence threatened those plans. "There was considerable resistance within NASA," says Martin Marietta's Molloy. "The enthusiasts were those who had worked on Skylab and were quite proud of it, but it interfered with the more global vision of glory shared by the later generation at NASA." Given a risky cheap way and an expensive fancy way, NASA (not for the first or last time) opted for spending a lot of money in the future rather than a little money immediately.

But could Skylab really have been revived? Most likely, yes. When it was turned on briefly by ground command in 1978, the station's power, command and control, and attitude systems all functioned adequately. Years later, when the Soviet Salyut 7 station died and froze, it was revived from conditions far more extreme—and then operated normally (see "The Rescue of Salyut 7," February/March 1990). NASA's Long-Duration Exposure Facility satellite, retrieved in 1990 after almost a decade in orbit, showed wear and tear but no serious damage.

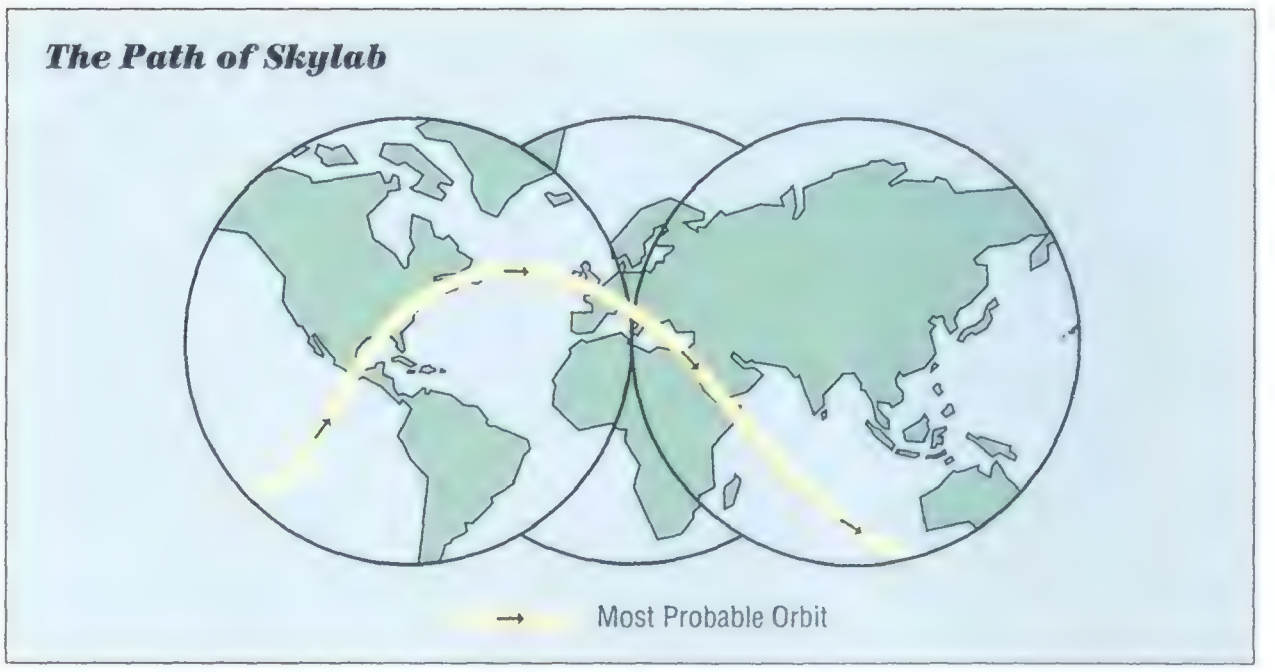
Would it have been worth the effort? Visits and brief experiments were possible, but the grandiose plans for converting the old station into a space city by small steps would have encountered serious problems. "Whether it was something to build upon was doubtful," says Robert Aller. "Skylab was '60s technology and I seriously doubt that anyone would have wanted to build onto that."

Originally, plans for long-term shuttle visits required the shuttle to shut off its fuel cells and use energy from the station. Later NASA decided that the shuttle would have to keep its fuel cells on line—there was too much danger that once shut off, a fuel cell might not restart properly in space. The long manned missions to Skylab originally envisioned probably wouldn't have been possible.

Perhaps the most damning argument against Skylab was something any real estate agent can appreciate: location. The high-inclination orbit (tilted 50 degrees from the plane of the equator) was not convenient for shuttle missions. To reach Skylab, a shuttle would have to be launched more to the north than usual, sacrificing some of the boost offered by Earth's eastward spin. That wasn't a major penalty for expendable spacecraft and boosters (about 10 percent of maximum payload weight), but because the shuttle carries its heavy wings and engines back to Earth, the weight sacrifices would have to come from the payload. (To avoid this unacceptable loss, Freedom is to be built in an easterly orbit from Florida, with an inclination of 28 degrees.)

But even with its drawbacks, a revived Skylab would have been a tremendous temptation to mission planners. Each incremental improvement—and all the expensive refurbishment and maintenance that would have become necessary year by year—would have seemed only a little bit more to spend. NASA would have been in the position of a poker player unwilling to walk away from the money he had in the pot even as the stakes went higher and higher. Would NASA ever have abandoned a revived Skylab to develop a newer design in a convenient orbit? Bureaucratic inertia might have made that unlikely.

Today the "what ifs" still tease, but the history is already written. Yes, operating a revived and refurbished Skylab would have provided valuable experience in space operations. It would have been better than nothing, which is what NASA has today—ironically, because the very sacrifice of Skylab was thought to be necessary to ensure future programs. One thing Skylab taught is that we should glance back from time to time to avoid old mistakes and gain inspiration from old successes. But to move forward into the future, we don't need to revive the past.



For a time the world held its breath as it waited to find out where Skylab would come down (above). Much of the space station eventually hit the western desert of Australia, where charred fragments were retrieved by souvenir hunters (below).

The battle took place on April 18, 1943, and lasted, at the very most, a few minutes. When it was over, Admiral Isoroku Yamamoto, the commander of Japan's combined fleet and the strategist behind the Pearl Harbor attack, lay dead in a South Pacific jungle near the wreckage of his Mitsubishi G4M1 "Betty" bomber.

Another battle began almost as soon as the American P-38 fighters that had attacked him returned to their base. In a sense, it was the old story of victors falling out over how to divide the spoils of war. But this time the spoils were not riches—they were fame, glory, and a chance for the history books.

Thomas G. Lanphier Jr., who died in 1987, insisted to the end of his life that he alone shot down the Japanese admiral. Rex T. Barber, Lanphier's wingman on the mission, is equally convinced that it is he who deserves sole credit. Over the years, as books, magazines, veterans' groups, and official military organizations scrutinized the Yamamoto mission and debated the question of credit, the two former friends and comrades-in-arms became increasingly antagonistic.

Amid the controversy, some facts are clear.

By April 1943, the war in the Pacific had shifted to favor the United States. Japan had suffered a decisive defeat at the Battle of Midway, and U.S. forces were beginning a slow but inexorable advance across the South Pacific. One of the linchpins in the American strategy was Guadalcanal, the second largest island of the Solomons. After weeks of bloody fighting, U.S. Marines finally took the island in February 1943, forcing the Japanese in the Solomons to retreat to Bougainville Island.

The Japanese had suffered another severe setback of which they were not yet aware. Years before, U.S. cryptologists had broken their naval code and gained access to Japan's top-secret radio transmissions. That access had been vital to the U.S. victory at Midway. So when American listeners intercepted a message that Admiral Yamamoto would be flying from Rabaul to Bougainville to visit his frontline troops, the U.S. forces knew where to go looking and exactly when they

UPI/BETTMANN

Sixteen months after Pearl Harbor, Isoroku Yamamoto (right) became the target of a still-controversial mission.

WHO SHOT DOWN ADMIRAL

JIM STORES

YAMAMOTO?

Nearly 50 years later, the question is still hotly debated.

by Tom Huntington

NASM (2)

Mission planners relied exclusively on Army Air Forces P-38s (above); no other U.S. fighter had the necessary range.

The P-38s' quarry was a Japanese Mitsubishi G4M1 bomber (right), better known to U.S. fliers as a Betty.

Lockheed P-38G Lightning

Two 1,325-horsepower Allison engines powered this single-seat long-range fighter to a maximum speed of close to 400 mph at 25,000 feet. The airplane had a range of about 350 to 460 miles, depending on speed; each Lightning on the 415-mile mission to intercept Yamamoto's bomber carried a 165- and a 310-gallon drop tank under its wings for added range.

would find him. The admiral was a very punctual man.

He was also one of the most hated men in the United States. In an article written for the *New York Times* after the war, Tom Lanphier described him as "a hater of all things American.... A conceited and arrogant man, Yamamoto, with a face like a frog but with a calculating mind that functioned precisely. An evil man with a personal calendar for the conquest of Asia and America." Overwrought as they were, Lanphier's words echoed the sentiments of many Americans.

The truth was quite different. Yamamoto, a brilliant bridge and poker player who had spent a year at Harvard and several in Washington as Japan's naval attaché, had long advised that Japan could not hope to prevail in a war against the United States. In early 1941 he told the Japanese prime minister that if Japan did attack the U.S., "we can run wild for six months or a year, but I can guarantee nothing as to what will happen after that." Now, 16 months after the Pearl Harbor attack, his worst fears had been confirmed.

On the morning of April 18, 1943, eighteen P-38 fighters prepared to take off from Guadalcanal's Fighter Two airstrip to intercept the Japanese admiral's flight over Bougainville. One pilot suffered a flat tire on the runway and a second had to turn back when his drop tanks wouldn't feed, but soon 16 of the twin-engine fighters were skimming above the Pacific waves on a circuitous flight.

They were led by John Mitchell, the commander of the 339th Fighter Squadron. Mitchell, a slim Mississippian who had already shot down eight Japanese airplanes, had received his orders only the day before and worked late into the night fine-tuning a course that would avoid Japanese radar and coast-watchers. He was navigating each leg of the 415-mile flight with nothing more than a wristwatch, an airspeed indicator, and a newly installed Navy compass.

If the million-to-one shot paid off and the U.S. fighters did intercept Yamamoto, Mitchell and 11 others would climb to altitude and fend off any attacks from accompanying Japanese Zeros. The remaining four pilots—Tom Lanphier, Rex Bar-

ber, Besby Holmes, and Ray Hine—were slated to attack the admiral's transport.

When it came time for Mitchell to select pilots for the mission, Barber and Lanphier had been obvious choices. On March 29 they had strafed and sunk a Japanese destroyer with their P-38s, a feat of derring-do that cost Barber several feet of one wingtip when he collided with the vessel's superstructure.

Though they worked well together in the air, the two men were quite different. Quiet and slow-speaking, Rex Barber had been born and raised on his father's wheat farm in Culver, Oregon. Lanphier, outgoing, confident, and reputed to be a social climber, was driven and ambitious. His father, Thomas Sr., had graduated from West Point and was friends with the likes of Douglas MacArthur and Henry H. "Hap" Arnold. Jimmy Doolittle, who had flown his famous raid on Tokyo exactly a year before the Yamamoto mission, was Tom Jr.'s godfather.

The flight to Bougainville was hot and monotonous, with nothing to see but ocean and sky and nothing to hear but the droning of the P-38s' twin Allison engines. Finally, just as the fighters reached land some two hours after takeoff, Douglas Canning broke the radio silence to call out, "Bogies! Eleven o'clock high!" Yamamoto was right on time.

As the top flight headed up to fly cover, Barber and Lanphier went in for the two Betty bombers, which were escorted by six Zeros. They attacked alone: Holmes and Hine had turned down the coast as Holmes frantically tried to shake off his drop tanks before joining them. As Barber and Lanphier were nearing the bombers, they saw a group of three Zeros drop their tanks and head down toward them. The two P-38s diverged, Lanphier heading up and into the Zeros and Barber continuing in toward the bombers. From that point on, the stories of the two pilots diverged as well.

Shortly before his death, Lanphier repeated his account of the combat in an interview for *High Honor*, a book that collected the stories of many World War II aviators. "In the ensuing five minutes or so I saw no one but my Japanese targets," he said. "First I set a Zero afire as it dived at me to fend me off from the lead bomber, which had dived down and away inland when his formation spotted Barber and me. Then I flipped over and chased the lead Betty for a couple of minutes, finally catching up with it over the jungle treetops and, with a lucky, extremely high-angle volley, set his right wing afire, finally causing the wing to fall off and the Betty to explode as it fell into the jungle."

Barber, on the other hand, recounts: "Tom broke left at 90 degrees up into the Zeros. I went on in. I banked real steep. I was in a little too close and a little too fast. I banked real steep trying to kill speed and so forth, rolled back, and there was a bomber slightly to my right. There was only one bomber. The other one had disappeared and I didn't know where it went. So I started shooting at this bomber and, as I reported, I shot it down. The right engine was smoking bad and it was going downhill very fast."

After he saw his bomber go into the jungle, Lanphier radioed Mitchell, up at 12,000 feet, to confirm his kill. Mitchell hadn't seen the aircraft go down, but he did see a column of black smoke rising from the trees. Barber, who found a flight of three Zeros on his tail immediately after shooting, says he didn't see the bomber he attacked crash.

In the melee, Barber followed another Betty out to sea and watched as Besby Holmes attacked it. Barber continued Holmes' attack, and the bomber exploded right in front of him and crashed into the water, showering Barber's P-38 with wreckage.

With both bombers destroyed, the P-38s turned back home. Of the 16 that flew the mission, only Ray Hine's was missing. It had disappeared at some point during the battle and Hine was never seen again.

Debriefings on Guadalcanal were usually fairly informal occasions; some pilots weren't debriefed at all, while others were at most asked a few routine questions. "Debriefing in those days was a very hit-or-miss type deal," John Mitchell says. "Nobody had taught us how to fight a war." The session following the Yamamoto mission was no exception.

It was at that informal debriefing that Barber and Lanphier had their first clash. As soon as Lanphier landed, Barber and Mitchell say, he went about loudly proclaiming that he "got Yamamoto." Barber heatedly pointed out that since no one knew which bomber was the admiral's, Lanphier's claim was groundless. Lanphier shot back, Barber says, calling him "a damn liar." (In a 1984 letter to his wingman, Lanphier concedes, "I may have been too harsh in calling you 'a damned liar' when you said my claim was ridiculous, but historical records bear out that I was right and you were wrong.")

By the time Besby Holmes, who stopped to refuel at the Russell Islands some 70 miles out, had returned to Guadalcanal, "Rex Barber and Tom Lanphier both claimed a bomber," he remembers. "And they were accorded credit by, I believe, Henry Vicellio [the lieutenant colonel who commanded the 13th Fighter Command]. And I believe Henry Vicellio sent an impromptu message to our higher headquarters confirming this. When I got back and Rex confirmed my Betty, they had to do some shifting of gears and they invented a third bomber and gave it to me." The final mission report

credited the flight with three Betty bombers and three Zeros. (Though the report was signed by intelligence officers, Barber believes it was actually written by Lanphier.)

The controversy heated up again in September 1945, when Lanphier published his account of the mission in the *New York Times*. After reading the article Barber telephoned Lanphier, who was working at the Pentagon, and berated him for what he saw as its inaccuracies. Lanphier responded with a three-page letter. "As you know," he wrote, "and as you will note I mention in my story, I am very much indebted to you, for my neck as well as other things. I don't know what I can do to remedy the situation—but I am certainly not happy that you felt you got shafted."

After the war, Japanese records proved that there were only two bombers on the flight and confirmed that Yamamoto's body had been found among the wreckage of the bomber that had crashed in the jungle. (They also indicated that no Zeros were downed over Bougainville.) In the 1960s the Air Force quietly redistributed the credit for the battle's victories, apparently without telling either Barber or Lanphier. Both men were given half credit for the bomber that carried Yamamoto, and Barber and Holmes shared credit for the one downed at sea.

Lanphier nonetheless remained faithful to his story and continued to be generally remembered as the man who shot down the Japanese admiral. However, sometime around 1979, Barber became convinced that he alone was responsible for the downing of Yamamoto. That year an English translation of *The Reluctant Admiral,* a Yamamoto biography that included information from a Japanese survivor of the mission, was published in the United States. Hiroshi Hayashi, the pilot of the bomber that crashed into the sea, said he recalled seeing tracer bullets come from above his cockpit, then watching a P-38 roar over his head as it fired into Yamamoto's bomber in front of him.

For Barber, it was as if a light bulb had gone on over his head. When he had banked to slow down, he had lost sight of the bombers and had seen only one when he returned to level flight. For years he had been unsure exactly which bomber he had been shooting at. Hayashi's account convinced him that his target had been the bomber that crashed in the jungle: Yamamoto's. The bomber containing Yamamoto's staff, which he and Holmes had attacked, had crashed in the ocean. As far as Barber could tell, Lanphier hadn't attacked the bombers at all.

Tom Lanphier, here being decorated for his role in the mission, insisted that he alone shot down Yamamoto.

Evidence from the bomber's wreckage (right) tends to support Rex Barber's version, though decay is gradually erasing it.

At 74, Rex Barber bears little resemblance to the daredevil fighter pilot of World War II. His hair is white, he moves slowly, and he suffers from diabetes. A seemingly placid man, he reminds one of a bull who, angered by taunts and challenges, has finally been goaded to charge.

For years, Barber's public stand had been that half credit was good enough for him, so long as Lanphier would accept it. Lanphier wouldn't. In the interview for *High Honor* he said, "I think [Barber] shot the same bomber down twice. He hit the one going toward the ocean, was distracted by the Zekes, and when he got away from them, shot the same Betty down. It was now out over the water." For his part, Barber now believed that Lanphier had deliberately misrepresented the day's events: that his account was a lie.

The bad feeling between the two men peaked at a meeting of the American Fighter Aces Association in Phoenix in 1984. After Lanphier made remarks that Barber thought attacked his credibility, he and John Mitchell refused to be photographed with Lanphier in front of a P-38. "I will not...stand still for your continued attacks on my statements in an ob-

vious attempt to discredit my honesty," Barber wrote to Lanphier after the event.

Now, with Lanphier dead and the record standing at a half credit each for Yamamoto's bomber, why is Barber still trying to change it? First, he says, "I was urged by people who knew and did not want it to go down inaccurately in history." And second, he says, there's the issue of Lanphier's book.

Until shortly before his death, Lanphier had been writing an autobiography, which he sent as a work-in-progress to people mentioned in it for comment. When Barber read a copy, he says he was especially incensed to see that Lanphier had largely ignored John Mitchell's role in the mission. "When I read it," Barber says, "I said, 'Well, I'm going after him.' "

After Lanphier died, Julius Jacobson, another mission pilot and Lanphier's roommate in flight school, attempted to act as peacemaker. "Barber said he's content to let it stay 50-50," Jacobson says, "but he's afraid that the Lanphier family is going to publish this book." Jacobson offered to ask the family for permission to edit the Yamamoto material so that Barber and Mitchell's stories were represented, which he says Barber agreed to. (Barber says he doesn't remember such a conversation.) "So I went to the family," Jacobson recalls, "and they said, 'Look, we're tired of this whole thing. The chances of ever publishing the book are nil and we just don't want to get involved anymore.' " (Lanphier's widow and five daughters have consistently refused to talk to the press about the Yamamoto mission.)

"So I went back to Barber and told him this," Jacobson continues, "and I guess it wasn't too long after that I started hearing about this Chandler guy."

George Chandler is one man who shares Barber's certainty that he alone shot down Yamamoto. In 1988 the Kansas banker founded the Second Yamamoto Mission Association, a non-profit veterans' group organized to gain Barber sole credit. Chandler is the group's president. With his thatch of white hair and silver-framed spectacles, he looks every inch the prosperous Midwestern businessman. He is also a P-38 ace and was stationed for a time on Guadalcanal, although he arrived after the Yamamoto mission. And he is, if anything, even more passionate about proving Rex Barber's case than Barber himself is.

For Chandler, the quest to get Barber sole credit has turned into a crusade. "Old Yamamoto Chandler," as he sometimes self-deprecatingly refers to himself, has written newsletters, gotten support from Kansas senator Robert Dole's office, and spearheaded an effort to get the Air Force to convene a new Victory Credit Board of Review. SYMA even found a pilot to take a Confederate Air Force P-38 through the maneuvers that Lanphier described in his accounts; the group determined that he could not have done them in time to catch Yamamoto's bomber before it went down in the jungle. Although civil unrest on Bougainville prevented a SYMA group from traveling there to examine the wreckage, they obtained videotapes from previous visits that clearly showed that both wings had been on the bomber when it went in, contrary to Lanphier's account, and that all the visible bullet damage came from the rear, the angle of Barber's attack.

In 1990 the Office of Air Force History ruled that Chandler's case did not offer "new, credible evidence" and declined to hold a new Victory Credit Board of Review. Chandler saw evidence of darker motivations in the decision. In a November 7, 1990 letter to Senator Dole he wrote, "It would

seem that there is a conspiracy within the Office of Air Force History to cover up the past dereliction of duty by Cargill Hall as Chief, Research Division, Maxwell Air Force Base, Alabama, in not energetically researching the new data about the Yamamoto shootdown but, rather, simply defending prior conclusions.

"And it would seem that there is malfeasance on the part of Dr. Richard H. Kohn as Chief of the Office of Air Force History in not convening a Victory Credit Board...."

Chandler wonders if perhaps an old boy network in the Air Force has worked to keep the Lanphier name from being besmirched, and has even suggested that a secret order in the files prohibits changing the credit.

Both Hall and Kohn deny the allegations. "I'm thoroughly convinced by the historical evidence that both deserve credit," Kohn says. "It seems almost certain that both fired at the plane while it was still in the air. Under the rules of the time, both would be given credit."

Kohn, who has since left the Air Force History Office to teach history at the University of North Carolina, questions Chandler's objectivity and wonders "whether there might not be some personal agenda, at least on Mr. Chandler's

Trek to the Crash Site

The young man in the orange T-shirt, a slingshot around his neck, introduced himself as Raphael Bukiri, son of Nu Nu. He would be our guide, he explained in pidgin English, to "the place where the airplane of the big man from Japan came down."

It was 1982 and I, an Australian pilot and writer, was on Bougainville Island on assignment for a magazine. I'd known that the wreckage of Admiral Isoroku Yamamoto's bomber lay somewhere in the jungle, and I was curious to see it. To reach this mud road near Raphael's village of Aku, where a local missionary had arranged for him to meet us, our mini-expedition had just spent six harrowing hours in a Jeep careening over Bougainville's mountainous backbone.

Within minutes of commencing our trek through the jungle we realized why Nu Nu, who had led the Japanese to the wreck in 1943, sent his son on this tour. The journey was not for the infirm (or the timid). In steambath heat we slogged, single file, through cloying mud as Raphael and his four teenage helpers blazed a trail with machetes. Twice their well-aimed slingshots sent overhanging tree snakes slithering away.

For an hour we negotiated a fetid swamp, frequently wading waist-deep in oily black water. As we stopped to remove the leeches we'd picked up along the way, someone broke the tension by wisecracking, "No wonder Tarzan swung though the jungle on vines."

After two hours we spotted a skeleton of vegetation-covered metal. It was the tall triangular fin and tail turret of a G4M1 bomber. Ahead in a small swampy clearing lay the corroding remains of the aircraft. The cockpit had been destroyed in the crash and both wings and horizontal stabilizers had been shorn off, but the rear fuselage was virtually intact. On either side and slightly ahead of the fuselage lay the two moss-encrusted engines and remnants of the right wing.

Although there was occasional evidence of souveniring—a propeller

TERRY GWYNN-JONES

"The journey was not for the infirm (or the timid)."

blade, for one, had been sawed off—Raphael said the site didn't attract many visitors, mostly Japanese men who'd fought under Yamamoto and struggled to the site to pay their respects.

When I finished photographing and sketching the disposition of the remains, Raphael led us about 50 yards to a dry, shady area. There lay the complete outboard section of the left wing. The damage indicated it had been torn off when the Betty first hit the jungle canopy. It was remarkably preserved, and only a little rubbing was needed to bring back the gloss on its rising-sun insignia. (The wing has since been moved to a Japanese museum.)

While we rested there briefly, Raphael recounted his father's recollections of the day Yamamoto died. Nu Nu had been working in a small clearing near Aku when the Betty passed low overhead, trailing smoke and under attack by a much smaller aircraft. Moments later he heard an explosion.

Climbing a tall tree, Nu Nu located smoke rising about a mile away, then set off to find the crash site. Reaching it, he found no survivors. Most of the occupants had been burned beyond recognition. One victim who had been hurled clear of the fire, however, was still strapped in an aircraft seat, clutching a ceremonial sword.

Nu Nu returned to Aku and found a Japanese road-building party. The following day he led the Japanese to the crash site. They removed the bodies and took them to the air base at Buin, on the southern point of Bougainville. According to Raphael, his father did not know until years later that the airplane had carried an important leader and that the body he had seen, sitting with strange serenity in its aircraft seat, was Admiral Isoroku Yamamoto.

During the hour I spent at the site I found no evidence that would enable one to conclusively solve the Yamamoto controversy. As a professional pilot, however, I had a vivid picture of what the final horrific moments of the flight must have been like. While Yamamoto had been a hated enemy of my father's generation, I experienced no sense of being at the scene of a celebrated victory. Rather I felt sadness, and the shock and pity that attend the witnessing of any violent death.

—Terry Gwynn-Jones

NASM

Barber began challenging Lanphier as soon as the mission was over, but his own claim for the bomber came years later.

part, against Tom Lanphier." (Chandler, who describes his wartime experience with Lanphier as brief and "very friendly," says he has "no ax to grind with Tom Lanphier at all.")

R. Cargill Hall, who, like Kohn, is a contributing editor of *Air & Space/Smithsonian,* comes across as more bureaucrat than conspirator, a soft-spoken scholar who doesn't seem likely to go out on any limbs or charge into any battles. "I didn't ask to get caught in this damn thing," he says of the Yamamoto controversy. He resents SYMA's implications that "I am really an historian with an ax to grind and I'm distorting history to deny somebody his due credit."

But to the members of SYMA, Hall's villainy is second only to Tom Lanphier's. Hall and Chandler first crossed swords in 1988, at a Yamamoto Mission Retrospective sponsored by the Admiral Nimitz State Museum of the Pacific War in Fredericksburg, Texas. Gathered together were all the survivors of the mission from the American side, plus Kenji Yanagiya, who had piloted one of the escorting Zeros. Hall moderated and, in Chandler's view, attempted to keep Barber's case from getting a fair hearing.

"So the next morning," Chandler says, "I went down to get a cup of coffee at the motel there, and here is Cargill sitting there talking to his wife and having a cup of coffee. So I, Old Brass Balls Chandler, just sat down and started talking to him."

What Chandler wanted to know was, if an expedition to the Yamamoto wreckage proved that both wings had been attached when it crashed and all the bullet damage had been inflicted from the rear, would the Air Force hold a new victory credit board? "Finally [Hall] said, 'George, I'd have to think for a long time before I could answer the question.' So then I got a long letter from him a month later saying he thought about it a lot, and it was a bureaucrat letter.

"So I became convinced then that these people are absolutely determined that they are not going to let Rex get his hearing. And I thought about that for quite a while. It made me just angry. And Rex was a good friend. I said, 'Hell, George. You haven't got any chips in this game. You're a banker out there in Kansas. You're getting along real well. Life is good to you.... I think I can get Rex a fair hearing.' And I really believed that even if Cargill Hall wouldn't give us a hearing, that there would be somebody in that Office of Air Force History that would."

In fact, the Office of Air Force History had already looked at the issue. In 1985 representatives of Tom Lanphier asked for and received a hearing on giving Lanphier sole credit for the shootdown. "So we looked at everything," Hall says of the 1985 review. "Clearly, only one bomber had gone down in the jungle and the evidence strongly indicated that Barber shot at it first. It hadn't crashed. Lanphier shot at it again and it crashed.... Shared credit under the circumstances was warranted."

If Barber is pressing his case in response to Lanphier's claims, what was Lanphier's motivation in trying to secure credit for himself? According to Barber, his original motive was simple: Lanphier had hoped to use the Yamamoto credit to catapult himself into the White House.

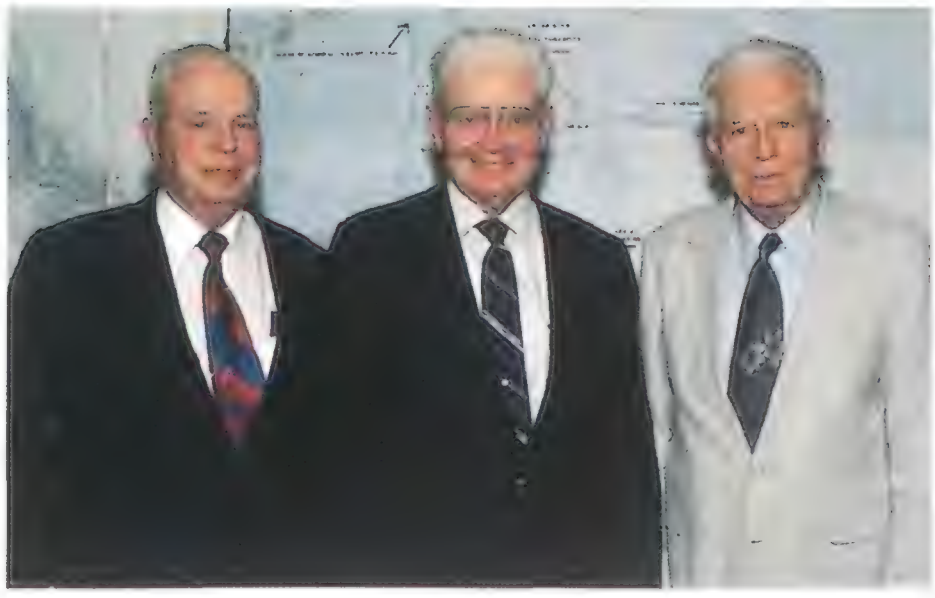
The story goes that in the summer of 1942, Lanphier talked himself aboard a B-17 and flew a mission as waist gunner. "He claims he shot a Zero down out of the waist gunner's position," says Barber. When Barber asked Lanphier why he'd risk his neck on such a mission, he says Lanphier told him, "I'm here for two reasons. One, patriotism. And the other, because I want to establish the greatest war record I can for myself and carry myself to the White House."

"I looked at him kind of funny," Barber says. "And he said, 'Wait. Hold on a minute. You know how many of our leaders have had unusual military experience and it carried them to the White House.' I couldn't argue with that. And he said, 'I'm going to do everything I can to establish this war record. If I kill myself doing it, so be it. But I want to leave here with the top record.' "

For a man determined to get full credit for the Yamamoto shooting, Lanphier was surprisingly candid about how unlikely his story was. The attack he described—firing at a 90-degree angle into the bomber's side—is universally acknowledged to be the most difficult shot a fighter pilot can make. In his accounts he stressed that he thought he was out of range, that he was surprised he hit the bomber, and that he considered his shooting "lucky."

"I think, personally, he honestly believed that he shot at Yamamoto's plane," says Jacobson. "I don't think he would out-and-out say 'I shot at this plane' when he didn't even pull the trigger."

Yet to the end Lanphier insisted that the bomber's right wing had come off, while examination of the wreckage shows



CAROLINE SHEEN (2)

Banker George Chandler, here flanked by Barber and John Mitchell, is leading the battle to award Barber sole credit.

that both wings had been attached when the bomber plowed into the treetops. Was Lanphier lying, as is SYMA's view? Or did he, during those few frantic moments, see the left wing torn off by the trees and assume that it was the right wing, the one at which he had been shooting?

Lanphier may have been his own worst enemy. Even Cargill Hall, whose position on the issue depends on Lanphier's credibility, concedes, "I think Lanphier liked to exaggerate." Says Jacobson: "I don't think when I knew him I ever caught him in an out-and-out lie. He would make it a little bit better or a little bit worse than what happened. That was his nature; that's the way he was."

For years, John Mitchell, the leader of the mission, kept out of the controversy. "No one on God's green earth knows who shot down Yamamoto," Mitchell told a San Antonio Rotary Club in 1946. It was an opinion he stuck to for more than 40 years.

"I couldn't care less who shot Yamamoto," he says today in his soft Mississippi drawl. "We went up there to get him and we got him. As far as I was concerned, that was it. The mission was over. I was very happy. So when they started arguing about it and everything, I really just stayed out of it. I didn't want to get involved."

Now Mitchell says he's convinced that Barber and Barber alone should get credit for the shootdown. He changed his mind, he says, after a 1987 squadron reunion in San Antonio, when George Chandler drove Mitchell and others over to the Admiral Nimitz Museum, which has a large exhibit on the Yamamoto mission. There they saw a videotape of a 1975 interview with Kenji Yanagiya, the pilot of one of the six escorting Zeros, and, as Mitchell remembers, "I almost fell off my chair."

Yanagiya had a vantage point none of the Americans did. What he said in the interview Mitchell viewed was that he saw a single P-38 attack Yamamoto's Betty from the rear—Barber's position—and shoot it down.

Yanagiya, who has said that he doesn't want to get involved in the credit debate, later confused the issue by telling participants of the 1988 retrospective that the attacking P-38s were "firing at the bomber and were just going in rows." In an attempt to clear up the matter, SYMA members had him sign an affidavit stating that he saw a single P-38 attack the Betty from the rear, then saw the bomber "descend in an attitude of forced landing" within 20 or 30 seconds. According to SYMA's calculations, Lanphier couldn't have caught up with it in less than 40 seconds. Nonetheless, Richard Kohn ruled that Yanagiya's new statement was "not credible."

The other survivor from the Japanese side, Betty pilot Hiroshi Hayashi, refused to discuss the matter after his version of events appeared in *The Reluctant Admiral.* Finally, in 1990 he granted an interview to Air Force historian Jay E. Hines and stated that he saw *two* P-38s attack Yamamoto's bomber, the first from the right, the second from the left, with an interval of a minute or two between the attacks. For Richard Kohn and Cargill Hall, this was the final bit of evidence they needed to support their position that both Rex Barber and Tom Lanphier had fired on Yamamoto's bomber.

Chandler, Barber, and SYMA reacted to Hayashi's statement the way the Air Force had responded to Yanagiya's affidavit. They were suspicious of Hayashi's sudden decision to speak with an Air Force historian and found his recollections riddled with inconsistencies.

And so it goes. Denied a chance for a new Board of Review, in June of last year Barber turned to his court of last resort and filed an appeal with the Air Force Board for the Correction of Military Records. Formed after World War II to deal with veterans' complaints about their service records and benefits, the board has never dealt with a victory credit case before. For two days last October, SYMA presented its case to five members chosen for the board. After it reaches a decision, the board will present its results to the secretary of the Air Force, who will then decide whether to change the credit or keep it as it is.

Barber (left), consulting with SYMA attorney Darrell Kellogg, presented his case to an Air Force board in October.

Whatever the decision, it's unlikely to be the final word on a topic that has been exciting passions for 49 years. To those concerned with larger issues, the question of who shot down Yamamoto will continue to be little more than a footnote to the large view of history. But human beings, as inconsistent and difficult as they can be, are history's raw material, and the close scrutiny given to the Yamamoto mission has demonstrated how fallible that material can be. Memory is a complex web of perception and desire. As a tool for reconstructing the past, it has limits.

The Smithsonian Traveler

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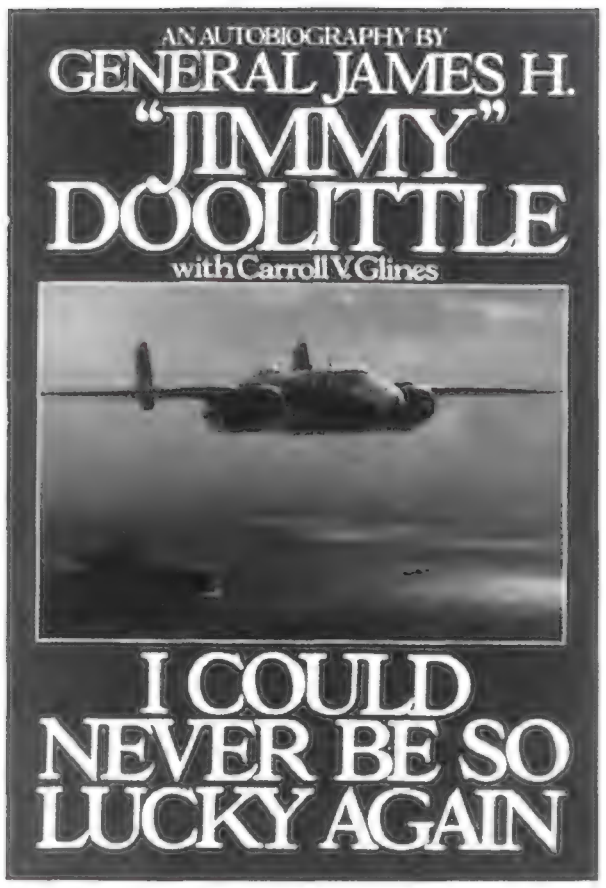


I Could Never Be So Lucky Again *by General James H. "Jimmy" Doolittle with Carroll V. Glines. Bantam, 1991. 539 pp., b&w photos, $22.50 (hardbound).*

Jimmy Doolittle was America's top combat air leader of World War II, commanding three different air forces: the 12th, 15th, and Eighth. Yet he is best remembered for the militarily insignificant but psychologically momentous raid on Toyko in April 1942. The raid has forever overshadowed Doolittle's far more important contributions. Though highly entertaining, this autobiography does little to correct that deficiency.

Doolittle decided to fly after seeing his first airplane at age 13, and he soon became a legendary pilot, earning international fame with his racing records and long-distance flights. His description of these years says much about the times; running out of gas, getting lost, becoming hypoxic, flying under bridges, "rum running" over the Mexican border, and crashing airplanes were common. Doolittle himself committed most of these sins, including flying with both ankles broken during an attempted acrobatic maneuver on a window ledge after several drinks, and riding along on a friend's landing gear just to prove he wouldn't fall off. It's a wonder he survived those years.

Nonetheless, Doolittle provided great service as a pioneer in instrument flying and as an aeronautical engineer. In the book's best chapters he describes the impact of air racing on the development of aviation and a September 1929 flight he made as an Army Air Corps pilot that was the first ever navigated completely on instruments, the landing included.

But service life during the Depression was not plush, so Doolittle left the Air Corps to become an executive at Shell Oil. He was in this position when recalled to active duty at the start of World War II. As a reserve lieutenant colonel he outranked those who had remained in uniform, and this, coupled with his selection to lead the Toyko raid, caused resentment. Henry H. "Hap" Arnold wanted Doolittle for this mission because of his piloting skills. What is not clear, however, is why he was then chosen to command the 12th Air Force for the North African invasion, the 15th Air Force for the Italian invasion, and

The Home Planet, *conceived and edited by Kevin W. Kelley for the Association of Space Explorers. Addison Wesley, 1991. 256 pp., color photos, $22.95 (paperback).*

Blue Planet: A Portrait of Earth *by Lydia Dotto. Harry N. Abrams, 1991. 64 pp., color photos, $19.95 (paperback).*

These beautiful, large-scale paperbacks share a similar theme: the appreciation of Earth we gain from a vantage point in space. The more inspiring of the two, *The Home Planet,* was a tremendous success when published in hardcover in 1988; *Blue Planet* consists of images from the popular IMAX film of the same name.

the Eighth Air Force for the D-Day invasion. Though Doolittle is silent on these questions, Dwight D. Eisenhower once described him as the man who grew the most while under his command. This ability, to learn and mature under the pressure of war while also providing solid leadership, was his greatest asset.

Candid as only the very old can afford to be, Doolittle admits his many mistakes over the years. His story is told in a disarming, self-effacing style and is filled with pithy and entertaining anecdotes. Most of his stories have been related elsewhere and some of the facts are muddled, but these shortcomings are understandable for a man in his 90s.

A more serious problem is that although the details of the story are provided, the big picture is not. There is little discussion of air strategy or targeting. The question of whether to bomb German rail lines or the petroleum industry in 1944 was of crucial importance, and Doolittle was a key player in that heated debate, yet he doesn't mention it. He never addresses the morality of area bombing or the part the Eighth Air Force played in the attacks on Dresden. Doolittle writes that his most important decision of the war was to direct Allied escort fighters to take the offensive against the Luftwaffe, but he does not recount his role in the development of the long-range fighter that made this aggressive policy possible. These are major omissions.

The achievements and exploits of Jimmy Doolittle will forever rank him as one of this country's greatest aviators, yet the man behind the circus stunts and glamour has eluded historians and does not completely emerge even in his own work. Above all he should be remembered as a magnificent combat leader who commanded some of the most important air units in World War II and always succeeded.

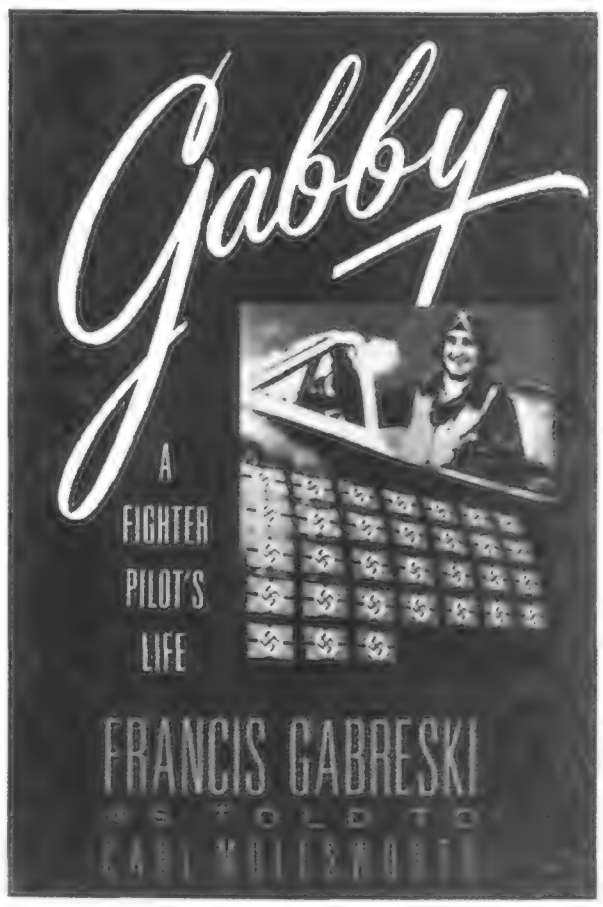
This is an enjoyable and entertaining read, but the real story of General Doolittle has yet to be written.

—Lieutenant Colonel Phillip S. Meilinger of the U.S. Air Force is a professor at the School of Advanced Airpower Studies at Maxwell Air Force Base in Alabama.

Gabby: A Fighter Pilot's Life *by Francis Gabreski as told to Carl Molesworth. Orion Books, 1991. 277 pp., b&w photos, $20 (hardbound).*

Some 50 years after the event, eyewitness accounts of aerial combat in World War II continue to appear. In *Gabby: A Fighter Pilot's Life,* Colonel Francis Gabreski makes it clear that the passage of a mere half-century is no impediment to a vivid re-creation of that chaos in the clouds.

Gabreski, a self-described "Polish kid from Oil City [Pennsylvania] who had almost flunked out of flight school," became America's top ace in the European theater. In the 11 months between August 24, 1943, and July 20, 1944, he shot down a record 28 Luftwaffe aircraft.



What brought that string of victories to an end (and Gabreski to earth) was not a superior German pilot but a rare moment of hubris on the part of Gabreski himself. During his 166th mission—he had passed up a flight home to volunteer for it—Gabreski came in too low while strafing some sitting-duck He-111 bombers on an airfield near Koblenz. The propeller of his P-47 fighter struck the ground, and he crash-landed in a field nearby. For Gabreski the war was over; he spent the rest of it in a POW camp on the Baltic Sea.

Gabreski's combat career, however, was far from finished. He became an ace again in Korea flying a radically different aircraft, the F-86 jet fighter. Despite the political and technological changes that had transformed the face of war since 1945, Gabreski stuck to his guns in Korea: "The aggressive style of combat flying had always worked best for me," he recalls. "Pull in close, give the target a heavy blast, then get out of the way. I decided good tactics were good tactics, regardless of the rules of the game."

And a good combat memoir is a good combat memoir, especially when it is written in a straightforward style that makes it easy to accept the author's self-effacing claims. "I didn't want to do anything in this world," Gabreski remembers, "but fly airplanes."

—Allan Fallow is an editorial director at Time-Life for Children.

Winter Training, *produced and directed by Paul Marlow. Threshold Releasing, Inc. (1-800-225-2376), 1973. 46 minutes, $19.95.*

Winter Training is an edited version of the 93-minute documentary *Threshold: The Blue Angels Experience.* The original was enthralling but too long and too costly—around $80 when it debuted in 1973. The recently released *Winter Training,* though half the length and a fourth the cost, is no less enthralling.

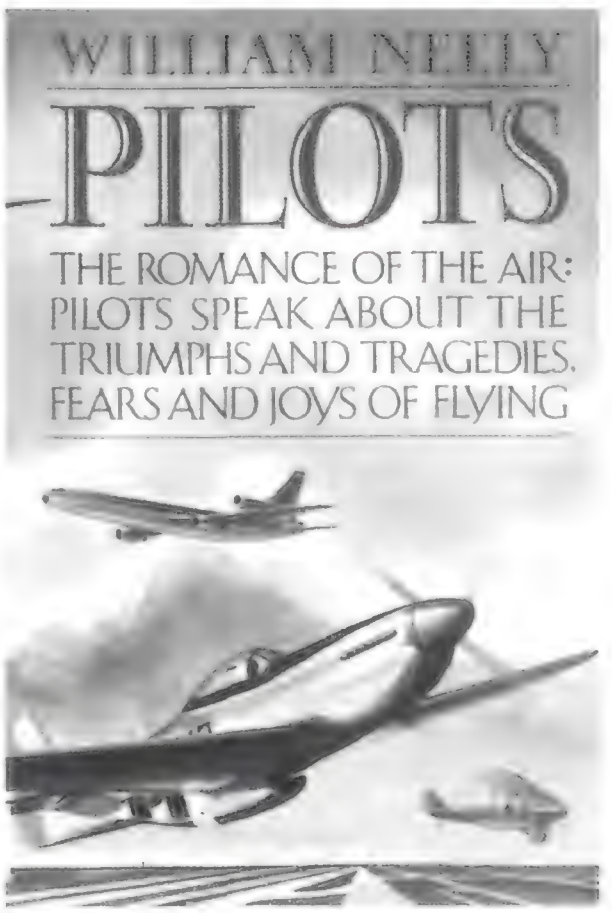
Narrated by Leslie Nielsen in pre-Lieutenant Drebin days, the video follows the Navy's demonstration team through airshows and training back when the McDonnell Douglas F-4 Phantom was the aircraft of choice. Today's F/A-18s are impressive and agile, but in achieving that agility they sacrificed the brutish appeal of the Phantom. Airshow crowds adored them—they're huge, they trail lots of smoke, and they're staggeringly loud.

What sets *Winter Training* apart from the numerous videos on military demo teams is the artistry of the footage and the frank talk of the pilots. Views from the cockpit during knife-edge passes induce vertigo. The view from the slot position, as the pilot nestles into formation mere inches from his teammates, makes you twitchy.

The usual public relations-induced banter about doing just what all Navy pilots are trained to do is replaced by refreshing commentary on how difficult and frightening this work can be. "That's very interesting, boss," says one pilot to the formation leader after performing a loop. "I just got down to 40 knots on top of that SOB." "Are you alive?" "Yeah, but I was scared!"

Winter Training is a tremendously satisfying and somewhat nostalgic video. It ends with the same awful song that its predecessor did, but then you can always hit the "stop" button on the VCR.

—Patricia Trenner is the departments editor at Air & Space/Smithsonian *and an F-4 fan.*



Pilots: The Romance of the Air *by William Neely. Simon & Schuster, 1991. 237 pp., $19.95 (hardbound).*

Are pilots special? Is flying in a different class from other human activities?

Author William Neely tries to answer these questions in *Pilots,* and he fails. He has interviewed a number of fighter, bomber, and helicopter pilots, stunt, airline, and crop duster pilots, a retired marijuana smuggler, and even some just plain private pilots; he seasons the brew with the odd toad of an anecdote or a fingernail clipping of historic background. The result is a random, uneven, and poorly edited concoction of hangar tales, reminiscences, and out-and-out canards, but it nevertheless provides some moving glimpses into the fliers' world.

Neely displays a devil-may-care indifference to historical and scientific fact. He places F-86s in Vietnam (they were used in Korea), attributes a top speed of 285 knots (about 328 mph) to the supersonic T-38, calls the Curtiss JN-4 "Jenny" trainer the United States' preeminent World War I fighter, and credits the Wright brothers with solving the problem of stalling and spinning, which in fact remains unsolved to this day. Even his epigraph is a blunder; he combines John Magee's "surly bonds of earth" with Gary Cooper's "Reach for the sky, podner!" and attributes the result to that prolific literary scapegoat, Anonymous. No yarn, however outrageous, awakens his slumbering incredulity; he relays as fact an elderly

crop duster's Paul Bunyanesque tale of being slingshot into a peach tree by a preternaturally elastic power line, and he accepts the claim of race driver Cale Yarborough that his airplane fell backwards 2,000 feet while being tossed about in a storm. Neely's indifference to fact and physics in some matters and his complete lack of skepticism in others leave the reader doubting everything he says.

To make matters worse, Neely does not make use of whatever gift of description he may possess. Never does he settle for the *mot juste* when he can use a cliché instead. What could have been a rich evocation of the feelings, sounds, and smells of flight instead comes off as a description of some utilitarian object, like a telephone handset or word processor keyboard.

Still, the voices of his subjects sometimes break through with what Neely himself fails to deliver. Some are vain, others self-deprecating; some trivial, others noble; some of the fighter pilots look back on war as a great game, others with a mixture of nostalgia, horror, and pity. The story of B-17 captain Charles Brown, and of the Luftwaffe pilot who flew alongside his flak-riddled bomber but chose not to shoot it down because he pitied the tattered airplane and the desperate homeward drive of its crew, is one of those grand tales that bring a lump to your throat. The chance to overhear stories like that is what makes *Pilots* worth reading.

—The author of several books on piloting and a frequent contributor to Flying *magazine, Peter Garrison has designed and built two airplanes.*

In Country: Folk Songs of Americans in the Vietnam War, *produced by the Vietnam Veterans Oral History and Folklore Project, Department of Anthropology, Buffalo State College (1300 Elmwood Ave., Buffalo, NY 14222). $9.98 cassette, $15.98 CD.*

This collection of 28 songs performed by combat veterans includes several ("Jolly Green," "Cobra Seven") with air war themes. All are said to have been popular among the troops, though some seem to have been favorites only within certain units. Authentic, not slick.

Credits

Off the Record. Elinor Smith, who made her first solo flight in 1927 at the age of 15, set records for speed, endurance, refueling, and altitude.

Dial-a-Planet. For his next vacation, Phil Scott hopes to save enough money for a long visit to London, Texas, or even Moscow, Kansas.

Rescue From Above. Breck Henderson is the military electronics editor for *Aviation Week & Space Technology*'s San Francisco bureau.

In Case of Emergency, Land at Banjul. Formerly the editor of *Spaceport News,* Beth Dickey now covers the space shuttle as a freelance writer for Reuters. She is also a contributing editor to *Final Frontier* magazine.

The Nuclear Option. Gregg Herken is the chairman of the National Air and Space Museum's space history department.

Come to Aruba When the Barium Blooms. Linda Shiner is the senior editor of *Air & Space/Smithsonian.*

Further reading: *Sun and Earth,* Herbert Friedman, Scientific American Library, 1986.

Origins of Magnetospheric Physics, James A. Van Allen, Smithsonian Institution Press, 1983.

Going With the Flow. William Triplett wrote "Getting Around on Mars" for the June/July 1991 issue of *Air & Space/Smithsonian.* He is co-author of *The Drug War: Voices From the Street,* which will be published next spring by William Morrow.

Skylab's Untimely End. James E. Oberg, a NASA space engineer, has written on all aspects of spaceflight.

Who Shot Down Admiral Yamamoto? Tom Huntington is the managing editor of *Air & Space/Smithsonian.*

Further reading: *Lightning Over Bougainville,* R. Cargill Hall, Smithsonian Institution Press, 1991.

Attack On Yamamoto, Carroll V. Glines, Orion Books, 1990.

Aviation's Fertile Crescent. George C. Larson is the editor of *Air & Space/Smithsonian.*

Calendar

February 12
"FAA's New R&D Plan," a symposium sponsored by the Air Traffic Control Association. Hyatt Regency Crystal City, Arlington, VA, (703) 522-5717.

February 22–March 29
"The View From Space: American Astronaut Photography, 1962–1972." Lakeview Museum of Art and Science, Peoria, IL, (309) 686-7000.

February 22–April 5
"Exploring the Planets." Lakeview Museum of Art and Science, Peoria, IL, (309) 686-7000.

February 27–29
Air Law Symposium. Sponsored by Southern Methodist University's *Journal of Air Law and Commerce.* Loews Anatole Hotel, Dallas, TX, (214) 692-2570.

March 2–4
Upper Midwest Aviation Symposium. Sponsored by the North Dakota Aviation Council. Seminars and a job fair for aviation careers. Radisson Inn, Bismarck, ND, (701) 224-2748.

March 5–7
National Convention of the Soaring Society of America. Charlotte, NC, (505) 392-1177.

March 16–20
23rd Lunar and Planetary Science Conference. Sponsored by the Lunar and Planetary Institute. Johnson Space Center, Houston, TX, (713) 486-2150.

March 19–22
Air race. Sponsored by the National Air Racing Association. Goodyear Municipal Airport, Phoenix, AZ, (805) 499-6184.

April 3–5
4th Annual Ozark UFO Conference. Inn of the Ozarks, Eureka Springs, AR, (501) 354-2558.

"The Satellite Sky" Update/28

These regular updates to "The Satellite Sky" chart will enable readers to keep their charts up to date. Additions can be clipped and affixed to the chart at the appropriate altitude.

New launches

90 to 300 MILES

300 to 630 MILES

630 to 1,250 MILES

21,750 to 22,370 MILES

Deletions

90 to 300 MILES

Cosmos 2156
down 11-17-91

Cosmos 2163
down 12-10-91

Foton 4
down 10-20-91

Progress M-8
down 8-17-91

Inoperative but still in orbit

300 to 630 MILES

Cosmos 2061

Launched but not in orbit

90 to 300 MILES

STS-44 US research	11-24-91	down 12-1-91

DATA: SAUNDERS KRAMER

Forecast

In the Wings...

Reno! Most people think of Reno, Nevada, as a place to get a quickie divorce, but aviation buffs know it as a venue for air races. Each year they flock to see propeller airplanes move as fast as propeller airplanes can. Maybe the races are to serious aviation what tractor pulls are to farming, but there's nothing else like them.

Space Camp. In space, nobody can hear you sing campfire songs.

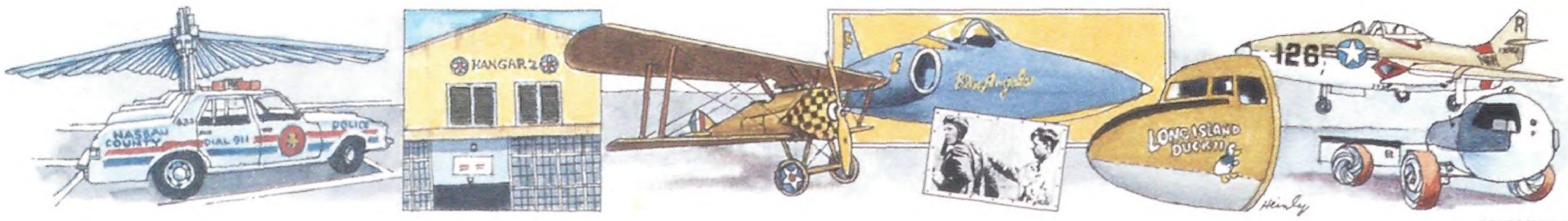
The Shack. Before they were finally retired last year, Britain's Shackletons made up the last frontline piston-engine squadron in the world. For airplanes so big, slow, and ugly, the Shacks still managed to elicit their fair share of affection.

Whispers From the Big Bang. Launched in 1989, a satellite called the Cosmic Background Explorer listens for the birth pangs of the universe. What it hears may tell scientists something about everything.

Satellite Rescue. What can Intelsat do when an expensive satellite gets stranded in a useless orbit? Hiyo, *Endeavour,* away!

Advertising for the Air Age. The Ford Trimotor made its debut in 1926, and although the airlines loved it, they had to sell it to a public uneasy about flying. Thus was born one of the most effective advertising campaigns ever.

The Name Game. To the Pentagon, the A-10 is a Thunderbolt, so why do people call it the Warthog? What was it about the XP-55 Ascender's name that made people snicker? Who put the Tom in the F-14 Tomcat? And does an F-111 by any other name fly like an Aardvark?



JOHN HEINLY

Aviation's Fertile Crescent

The airplane was born at Kitty Hawk, North Carolina, but Long Island's Nassau County lays claim to having nurtured it through its infancy. The county has even adopted a label with a Chamber of Commerce ring: it calls itself the Cradle of Aviation.

In April 1991, Nassau County, with support from the Friends for Long Island's Heritage, opened an air and space exhibition called—no surprise—the Cradle of Aviation Museum. The collection, which focuses on Long Island aerospace companies, heroes, and heroines, is impressively complete, though the buildings housing it need work. There's no heat in the old hangars, so the facility operates only during the mild-weather months, but plans call for modernizing the museum to a spiffy state. Once a visitor is made aware of where he is, however, the site itself stirs the spirit—and some ghosts from the early years of aviation.

In July 1909 Glenn Curtiss left his Hammondsport base in upstate New York for Long Island's Hempstead Plains, a flat, grassy expanse near Mineola. He brought with him the *Golden Flier,* which he had just completed for the Aeronautic Society of New York, a group of aviation enthusiasts who had ponied up $5,000 to purchase the object of their affections. Between the flying lessons Curtiss gave society members at an area dubbed the Washington Avenue field, he fine-tuned his flying for the upcoming Gordon Bennett trophy race in France. Later that month, Curtiss won for the second year the *Scientific American* trophy, the first offered in the United States for heavier-than-air flight, with a 52-minute flight in the society's brand-new airplane.

During the next 20 years, a series of thriving airfields (the word "airports" had yet to be coined) turned this country crossroads 20 miles east of New York City into the aeronautical center stage for the eastern United States. Next door to the field where Curtiss mastered the *Golden Flier,* another piece of table-flat ground became the Hempstead Plains Field, the site of the Moisant School, the first civilian flying school in the United States. Hempstead Plains underwent several incarnations—Hazelhurst Field, Curtiss Field—before it was expanded to become Roosevelt Field, departure point for Charles Lindbergh's transatlantic flight. Across Stewart Avenue to the south, the Army established Mitchel Field in 1917.

As a burgeoning New York City populace spilled eastward, Long Island lost its rural character. Today Nassau is synonymous with suburbia, and airports are an endangered species. A shopping mall, a racetrack, and the Meadowbrook Parkway have replaced Roosevelt Field, and Mitchel Field is more like a neighborhood, with two college campuses, a sports arena, and various government offices, including a huge maintenance facility for police cars.

But the sites of those famous old fields are within walking distance of the museum. Look for the signs for what used to be Mitchel Field, then search for a building marked "Hangar 2." Enter the opening in the tall sliding doors and you're in the middle of the collection, which owes its start to George Dade.

Dade has a 1928 photograph that could be captioned "The Man Who Touched Lindbergh." It shows the callow 16-year-old Dade in greasy coveralls reaching out tentatively to assist the Lone Eagle into his parachute. Lindbergh looks preoccupied, as if he could have been ordering fuel. But their fates had been linked, and Dade would eventually find Lindbergh's Curtiss Jenny on an Iowa farm and refurbish the craft. In 1973 he met the great flier for a second time to show him the ongoing restoration of his first airplane, which is now the keystone of the Cradle of Aviation collection.

The early aircraft—many are replicas, such as a Wright EX and a Sperry Aerial Torpedo—are eclipsed by the preponderance of later Long Island-built designs, particularly Grumman and Republic fighters. The sheer size of the Republic F-105B Thunderchief distracts visitors from the rare and original Peel Z-1 Glider Boat of 1930. A Convertawings Quadrotor adds kinkiness, and the presence of the Fairchild-Republic T-46 Next Generation Trainer from a failed 1980s Air Force project demonstrates that the collection isn't limited to successes. A coin-operated fly-the-helicopter game that belongs in front of a K-Mart suggests that somebody here has a sense of humor.

Grumman had a leading role in the Apollo program, which explains why two lunar modules and an ascent stage are the stars of the spacecraft exhibit. A large spherical shape resembling a helicopter's bubble cockpit turns out to be the front end of a Grumman lunar truck.

In a retired fire station next door, volunteers work on restoring artifacts. WHLI plays Tommy Dorsey and Keely Smith while a craftsman gently hammers a bowl shape in aluminum sheet. Another coveralled mechanic wrestles with a big radial engine destined for an F4F Wildcat. He looks up, grins, and says in pure Noo Yawk, "Amazin' the work people will do for no money."

According to curator Joshua Stoff, the most recent acquisition is a 1946 Republic P-84B Thunderjet. "The oldest Long Island-built jet," he says. "This one was the eighth production airplane, and it came off China Lake, where it was a target for the Navy. It was hit by a bomb, but then the Navy realized it was historic and saved it." Stoff has a long shopping list, and he's optimistic. So far, he says, "we've gotten every one we went after."

The upgrading of buildings and facilities should get serious this year, when the museum operators start soliciting bids. "People were surprised when it was delayed," Stoff says. "We're doing all right." The museum, he says, is "very low key, word of mouth, and there's no advertising, but we're doing okay."

—George C. Larson

Cradle of Aviation Museum, Museum Lane, Mitchel Field, Garden City, New York. Phone (516) 222-1190. Open Friday through Sunday, April through October, from noon to 5 p.m. Admission free.

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